


metal finishing

PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING,
GALVANIZING, METAL SPRAYING and all METAL FINISHING PROCESSES.

Vol. 7 No. 73 (New series)

JANUARY, 1961



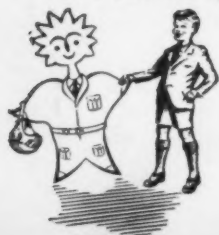
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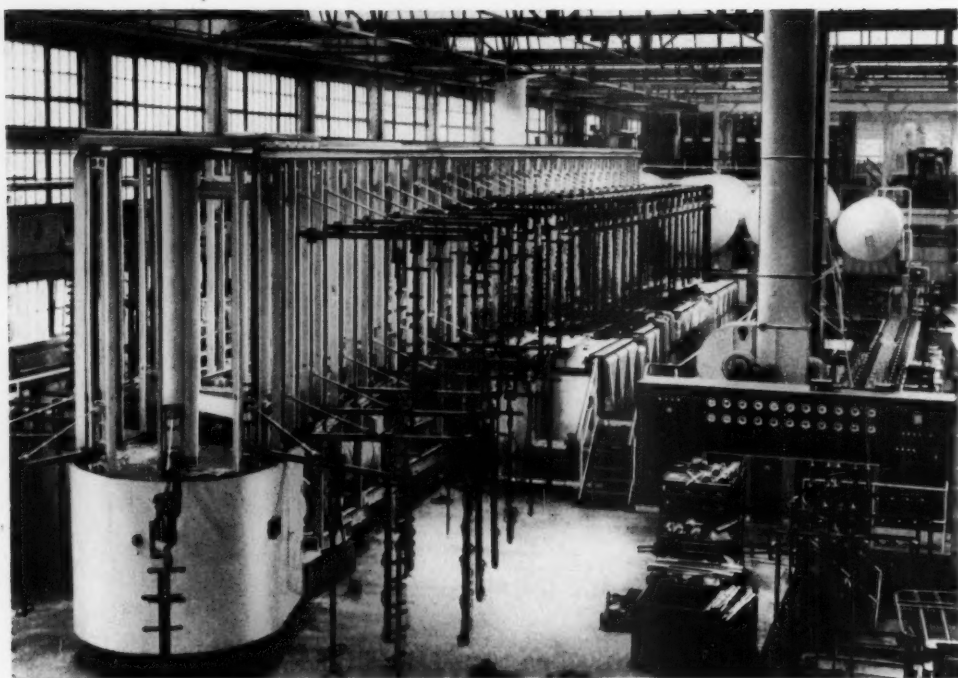


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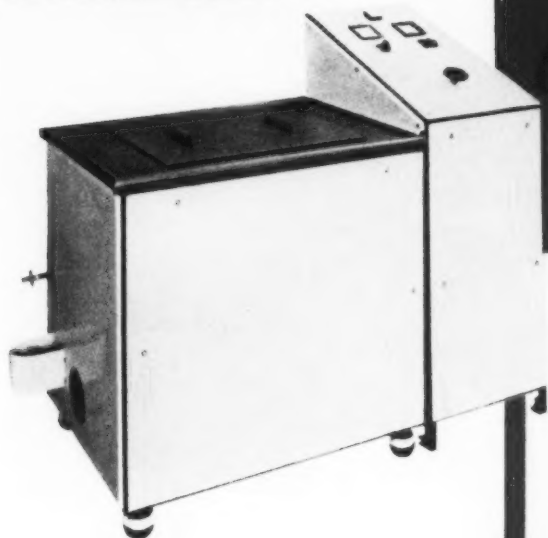
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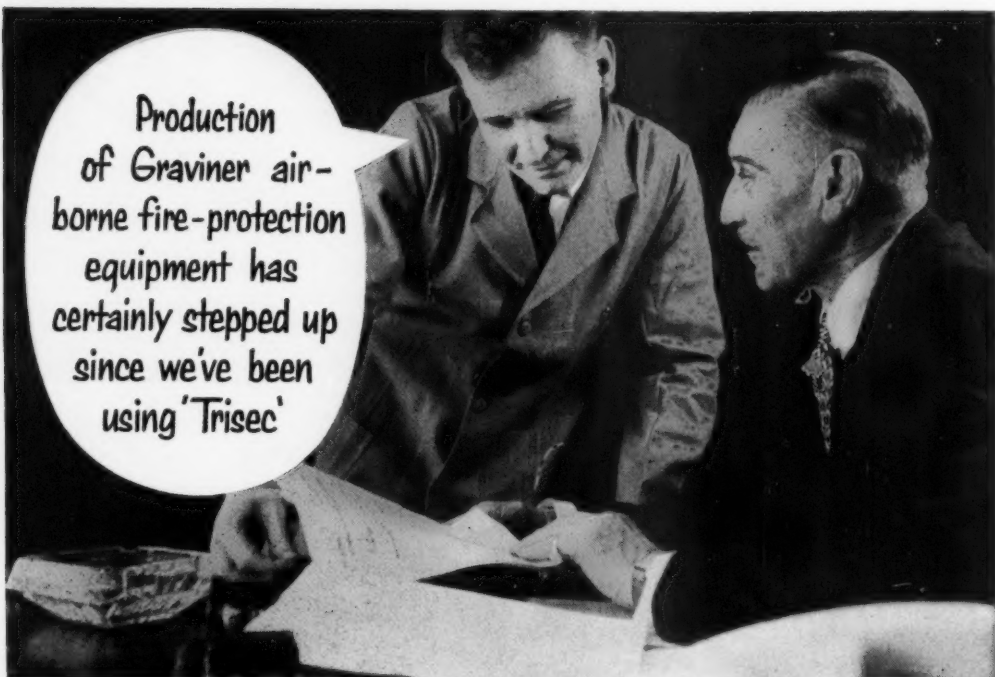
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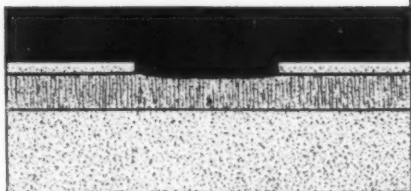
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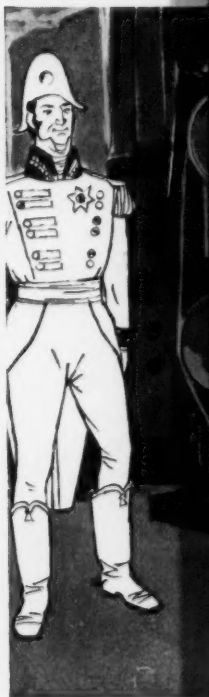
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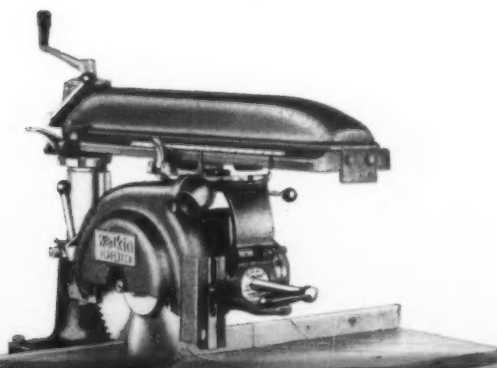


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january, 1961

metal **finishing** journal

11



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Metal Finishing...

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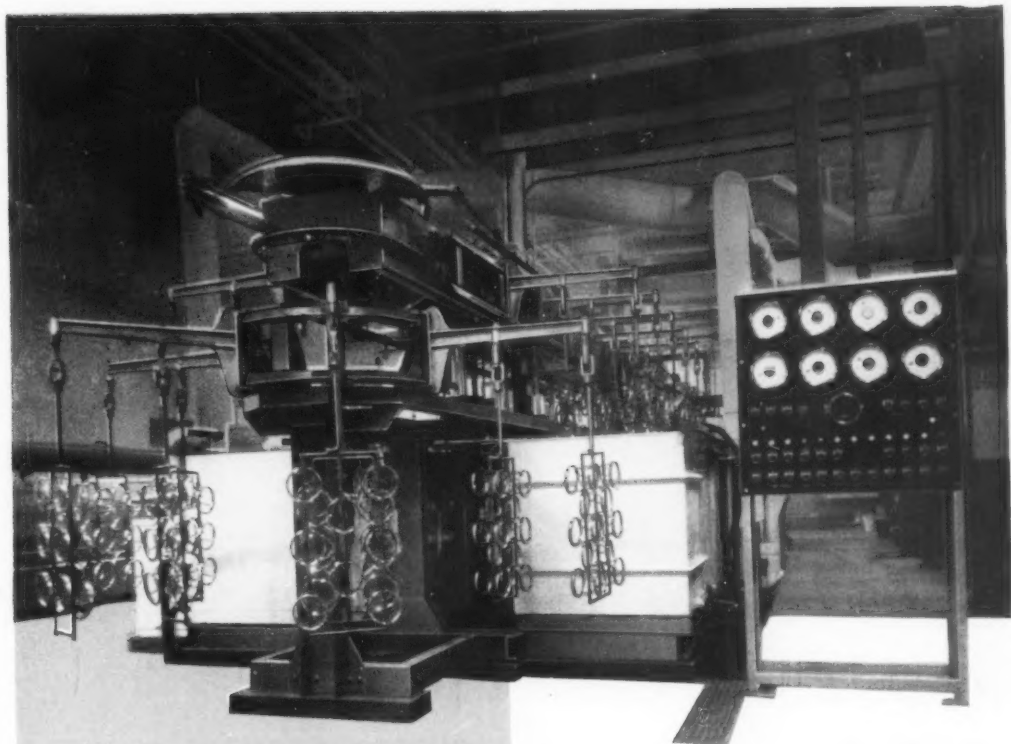
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In less than 2 years, nearly 50 Canning automatic plating plants have been ordered or installed for handling components ranging from hard chrome plated cylinder liners to cadmium plated gramophone gear wheels.



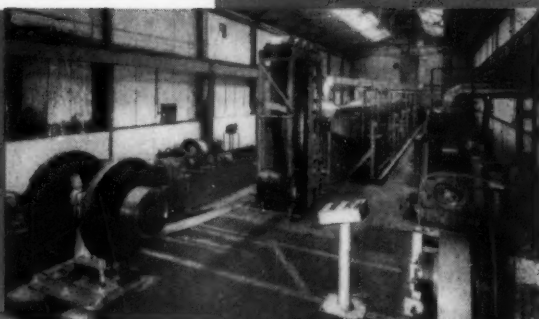
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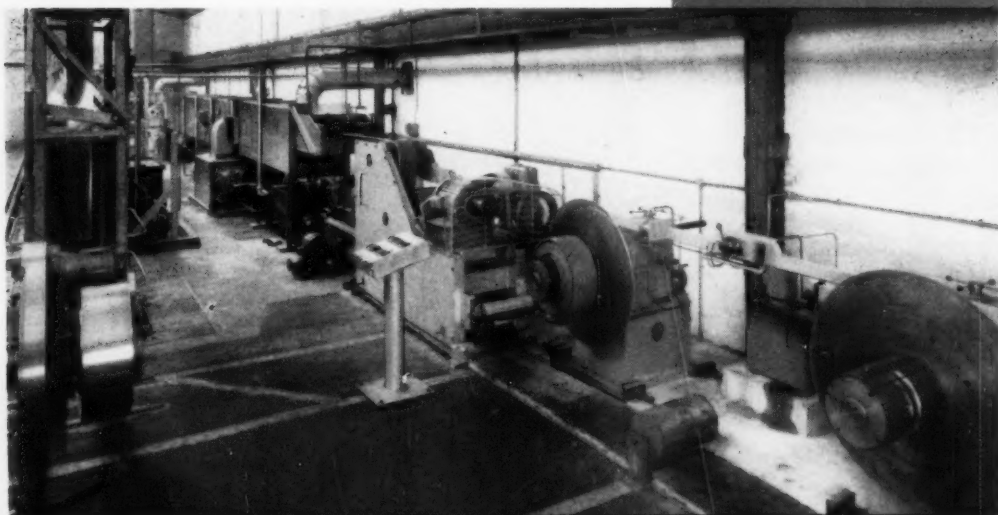
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THIS JOURNAL IS DEVOTED TO THE SCIENCE AND TECHNOLOGY OF PAINT APPLICATION, ELECTRODEPOSITION, VITREOUS ENAMELLING, GALVANIZING, ANODIZING, METAL SPRAYING & ALL METAL FINISHING PROCESSES. THE EDITOR IS PREPARED TO CONSIDER FOR PUBLICATION ANY ARTICLE COMING WITHIN THE PURVIEW OF "METAL FINISHING JOURNAL" AND ALL SUCH ARTICLES ACCEPTED WILL BE PAID FOR AT THE USUAL RATES.

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RUST DOTH CORRUPT

THE story is told of the aged metal finisher who felt that his end was near after a long and blameless life spent in the innocent pursuit of his calling (any resemblance to any reader of this Journal is purely fortuitous).

With the hand of Death heavy upon him he suddenly launched out into a most uncharacteristic round of debauchery in which wine, women and song were merely minor elements. This caused considerable concern and comment among his former associates who came to him and urged him to forsake his wanton ways and repent while there was yet time. Alas! exclaimed the errant electroplater, I have barely enough time as it is. If I can't get a black enough character before I go, its the pearly gates for me, and how can a metal finisher earn an honest living up there where rust doth not corrupt?

While the old boy may have got his conception of life in the hereafter a bit distorted, it is certainly true that the predilection of metal for combining with their environment has been responsible for the foundation of many thriving industries. Once upon a time the result of this tendency was known as Rust, which was not taken very seriously but accepted as one of the features of life on earth, like Gravity or the East Wind. Then, rather suddenly, Rust acquired status and aspired to the title of Corrosion, while several societies of learned people were set up to study and subscribe to its whims and vagaries.

This elevation to the peerage has endowed Corrosion with a much enhanced degree of influence in both industrial and technical circles and considerably more attention is paid, at least superficially, to its requirements. In fact, so much is now being said and written about corrosion, that there is some danger of it joining such other subjects as Technical Education and Export Sales in that limbo of subjects which are frequently discussed but about which little really effective action appears to be taken. Some colour is lent to this possibility by a study of the programme of the International Corrosion Congress scheduled for the Spring of this year. This programme includes, in addition to visits to a number of works and laboratories, provision for the presentation and discussion of over eighty technical papers. One can appreciate that for an International Congress, to which it is hoped to attract a very substantial attendance, the programme of technical papers is in effect the shopwindow, but it is also fair to assume that people attend such meetings to gain information, increase their knowledge and clarify their thinking. One may well wonder whether the feelings of the average delegate at the end of the Congress will not be one of bewilderment and surfeit.

It can hardly be avoided that in so great a number of contributions there will be considerable duplication and overlapping of subject matter and that in the time available the discussion of the papers will be stultified and desultory.

We note that one author has entitled his projected paper "What I would Like to Know About Corrosion." It is to be hoped that he will not depart from the Congress with too many of his questions unanswered.

Talking Points

by "PLATELAYER"

TOPICAL COMMENT
FROM THE MAIN
LINES AND SIDE
LINES OF METAL
FINISHING

BELIEVE IT OR NOT

MOST technologists in industry have from time to time been surprised at some of the curious notions which their less technically qualified directors pick up, and wondered where they get their information from. A likely source might well be the Journal of the Institute of Directors, which is sent each month to some 30,000 directors. This publication recently described an installation for cathodic protection in the following fantastic terms:

"The hull of the Windsor Castle has been studded at calculated intervals with anodes or dome-like shapes of cast magnesium. The anodes attract the corrosive particles in sea water. After the anodes have wasted away (this happens relatively quickly) they leave behind an electrostatic field, which protects the steel of the hull."

Another paper which gives potted accounts of technical developments is the "Financial Times" from which we have culled strange items from time to time. The other day a new compound for rust protection was described thus:

"The operation of the material depends on the fact that anodic metal particles are suspended in a plastic medium."

If these were isolated examples of the kind of technical writing one finds in the commercial and financial press, it would matter little, but, unfortunately, they are almost typical. It is a great pity that those responsible for such periodicals do not take anywhere near enough care to ensure that the quality of their technical contributions is of a sufficiently high level. It is quite evident that, as often as not, the writers have no cognisance of the subject matter.

CORROSION WITHOUT PROTECTION

LOOKING at the recently issued official programme of the 1st International Congress on Metallic Corrosion to be held in London in April 1961, one cannot help being struck by the fact that out of some 80 papers being presented by authors from all over the world only about 10 per cent deal with any aspect of protective coatings at all. In view of the importance of protective treatments in relation to corrosion, this is, to say the least, surprising. It will also tend to make the Congress of limited interest to those concerned with metal finishing, either organic or inorganic.

Incidentally, the first lecture is to be given by Prof. Y. Kolotyarkin, of the U.S.S.R., to a Plenary Session and is entitled "Electrochemical Behaviour of Metals on the Anodic and Chemical Passivation in Electrolytic (*sic*) Solutions." What this curious title is intended to convey, I have not the slightest idea. But perhaps the learned professor has been let down by his translators.

MATHEMATICAL EXACTITUDE

THE plating industry has long been interested in the possibility of electrodepositing an alloy corresponding to austenitic stainless steel, i.e., an iron-chromium-nickel alloy containing 18 per cent. chromium and 8 per cent. nickel. It is therefore interesting to see some recent German papers in which the authors claim to have achieved this successfully from a bath containing sulphates of chromium, nickel and iron with about 180 gm. per l. of urea. A current density of 100 amp. per sq. ft. or more is used, but the cathode efficiency seldom exceeds 26 per cent.

The authors have apparently determined the optimum concentrations of the respective metals in the plating bath with wonderful precision and give them in grammes per litre to two places of decimals! Even if they have arrived at these figures with the aid of a computer (which I doubt), do they really expect to maintain this solution composition in practice?

WET THINKING

A CORRESPONDENT in the Evening Standard recently complained to the manufacturers that the top fittings of her nylon covered umbrella had rusted. She was told that this was inevitable, as the porous nylon fabric allowed water to get through to the metal parts. They were striving hard to get a tightly woven nylon cover which would be waterproof, and thus eliminate rusting of the fittings.

This is typical of the naive approach to corrosion problems on the part of many manufacturers. It has apparently never occurred to the makers that (a) rusting of these fittings could be prevented in spite of an incompletely waterproof covering, and (b) that in all probability the present fittings will continue to rust even with a waterproof fabric. Anyone who designs an umbrella on the assumption that only its cover will ever get wet should not be in the business.

THIRTY-FIVE YEARS OF OUTPLATING EXPERIENCE

A Description of Plant and Techniques at the Battersea Factory of **ATLAS PLATING WORKS LTD.**

Introduction

ATLAS Plating Works Ltd., commenced trading in Acton in 1926 and continued to expand until the ever-increasing growth of the plating industry made it necessary for them to obtain additional premises. Consequently, some eight years ago the Battersea factory was purchased, having a floor space of 17,000 square feet. The company were then able to devote 80 per cent of their new acquisition solely to barrel plating and are now in the position of being the largest out-platers in barrel plating south of Birmingham.

The company were the first outplaters in London to instal a barrel-chrome plating plant and a sound policy of keeping abreast of modern developments in equipment and processes has lead to the introduction of all types of barrel plating. The company were also the pioneers, among the out-platers of the country, of the Rotofinish process for the deburring and burnishing of parts prior to electroplating, which served to eliminate the high cost of hand polishing.

Articles too large for barrel plating are processed in a semi-automatic nickel-chrome plant at the

Fig. 1.—Layout of the Battersea barrel shop.

- Legend
- 1 to 11 Cadmium
 - 12 to 13 Brass
 - 14 to 22 Zinc
 - 23 to 25 Potassium Stannate Tin
 - 26 to 30 Copper
 - 31 to 44 Nickel
 - 45 to 50 Chrome
 - 51 to 52 Silver
 - 53 Acid Tin
 - 54 Bright Tin
 - 55 to 60 Barrel Polishing
 - 61 Bright Dip
 - 62 Phosphate
 - 63 to 64 Tool Treatment B'lack
 - 65 De-Watering Oil
 - 66 Burnishers
 - 67 Sorting Room
 - 68 Lacquer Shop
 - A Trichlorethylene Degreaser
 - B Dawson Cleaner
 - C Emulsion Cleaner
 - D Alkaline Rinse
 - E and F Pickling Acids
 - Dryers
 - ⊗ Germanium Rectifiers
 - x Selenium Rectifiers
 - Trisec Dryer



Fig. 2.—Work entering the shop on a roller conveyor.



Battersea works and in August last year a fully automatic plating plant of Dutch design was installed at Battersea and will be the subject, with the still lines, of a further article.

The Acton factory of Atlas specialize mainly in nickel-chromium finishes, cadmium, zinc, anodizing and precious metals. They also have a large plating shop, used entirely for hard-chromium deposition, which is in operation night and day.

An efficient delivery service is maintained for both sections of the company, particularly in the greater London area, by a fleet of nine vans.

The Battersea Barrel Shop

The entrance to the Battersea Works is dominated by a conveniently situated bay (Fig. 1) to handle the loading and unloading of goods, destined for both barrel shop and still-tank line. Most of the work is small enough to be man-handled but fork-lift and platform-lift trucks are available to deal with the heavier loads. A considerable amount of space has been saved by this type of centralization, and is a valuable asset to a shop of this nature.

Work coming into the shop is received on a roller conveyor from the vans (Fig. 2), and the warehouseman fixes a card to each job, giving the relative plating details and coloured according to the type of plating required. This colour code is one of the more recent ideas conceived by Atlas and its scope is still being investigated. The general idea is that the colour given to the work follows it for the rest of its life in the works by means of suitably shaped tags attached to the plating baskets, to indicate whether the item has to be plated to commercial or A.I.D. specifications and ensures that the necessary pretreatments are

incorporated. The colours in use at the moment are :—

Red	Nickel
Yellow	Cadmium
Green	Nickel for chrome
Blue	Zinc
White	Tin

Once the work has been formally received and the necessary details recorded, it is placed in specially-made metal trays with inserts to take the coloured cards and stacked in vertical racks immediately in front of the reception bay. Each rack is confined to one type of plating. They are left here until the work is required for plating, the incoming trays being moved gradually to the end of the rack as the preceding work is taken away for processing.

On reaching the end of the rack the work is taken away for cleaning. The cleaning section deals solely with degreasing and pre-plating treatments, leaving the plater free of this phase of the work. The section comprises a Dawson cleaner, a trichlorethylene plant, an emulsion cleaner and the accompanying alkaline soak. The bulk of the work is handled by the Dawson cleaner, which propels the items into a perforated, rotating drum where it is sprayed with hot alkali. The medium quantities are processed in the emulsion cleaner and alkaline soak, while the smaller quantities and work too large to be basketed is degreased in the trichlorethylene plant. This is standard practice with the exception of work to be silver plated which goes through the trichlorethylene plant and is handled by the plater himself.

After degreasing, the work is made up into convenient loads and placed in baskets. The

appropriate coloured tags are wired to the handle of the baskets which are placed in dwell tanks to await plating.

All the steel-based items are first progressed through pickling tanks of which there are two types available. One is the normal acid type and the other contains additions of inhibitor where the scale on the steel calls for extended pickling times. A dilute sulphuric acid bath is also available in which badly-scaled components can be left over-night. Other non-ferrous components are cleaned in a bright acid dip.

Most steel components destined to be nickel plated are first burnished in a section at the far end of the shop. The section has ten large open-end barrels and two midget barrels. The burnishing acts as an extra cleaning operation for the steel and helps to improve the colour or brightness of the deposit. Dwell tanks and dilute sulphuric acid swills are available in the section to neutralize the alkali content of the burnishing solutions.

The barrel shop itself, can more or less be divided into two sections with respect to the plating solutions used. The majority of solutions in the top half of the layout diagram are of the acid type while in the bottom half of the diagram they are mainly cyanide. Starting with the cyanide section, the barrels on the right, Fig. 3, are for cadmium plating. There are three midgets and four open ends all fed from a common plating solution tank, which helps to maintain a uniform colour of deposit and also makes control of the solution to these barrels much easier.

Four large, totally immersed barrels are available for cadmium plating in the line directly opposite. They have a capacity of about 100 gallons each and the solutions are prepared as the occasion arises to suit any particular specification. It will

be noticed that throughout the shop the policy of having midget, large and totally immersed barrels, is adopted on all sections and makes the scope of the work undertaken, much wider.

Zinc barrels occupy most of the remaining part of this half of the shop, the section consisting of one midget, two Alkan barrels for medium quantity work, and five totally immersed barrels which handle the bulk of the zinc plating work. All the solutions used for zinc are of the bright variety and the company has achieved a very high standard of deposit. Facilities for chromate passivation are, of course, available for both zinc and cadmium deposits and an interesting point has been found by Atlas that the best passivations results are obtained if separate dips are used for zinc and cadmium.

A small amount of tin plating is done, in three small barrels. Again a common solution is used in an attempt to maintain a uniform colour and impart a consistent deposit to the component. The tin plating is in line with the modern conception of barrel tin, in that a potassium stannate solution is used, which the company consider to be a vast improvement on the more usual sodium stannate solution.

Another process of which Atlas have built up over a number of years, is brass plating. The section comprises two open-end barrels both fed from one large tank of plating solution. The bulk of the brass plating work is done on a nickel undercoat, but a considerable amount is also done on a copper undercoat. The general high standard of barrel nickel done here is largely responsible for the correspondingly high standard of this brass flash, which is considered almost equal to that obtained from still vat bright brass. The copper



Fig. 3.—View of the cadmium line, looking towards the main shop.

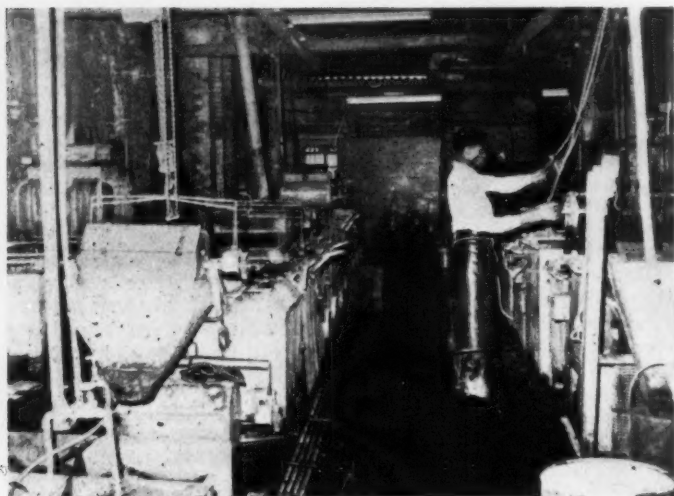


Fig. 4.—General view of the nickel line showing the three individual lines.

undercoat is used when brightness is considered a secondary feature of the finish.

Copper plating is of considerable importance and facilities for large quantities of this type of plating are available. Its main use is, of course, as an undercoat for nickel, since it eliminates much of the bad adhesion properties of leaded brass components encountered when nickel plating. The layout has been planned so that there are three large copper barrels housed in the main nickel line, while the copper for bronzing is handled by two midget barrels, both open-enders, with adjacent oxidizing solutions.

The nickel section, Fig. 4, occupies practically the rest of the top half of the shop and its use as an undercoat for chrome, has made it necessary

to have a large nickel section. It consists of four midget barrels, four medium-sized semi-immersed barrels, and six large totally-immersed barrels. It can be appreciated how the position of the three copper barrels greatly reduces production times by housing them in the nickel line. All the solutions used are of the high sulphate type and are made up individually in the laboratory with varying amounts of addition agent according to the finish required. One barrel is kept specially for the deposition of ductile nickel where components still have to be worked after plating.

The chrome line, Fig. 5, is situated at the far end of the shop. At the moment, the line includes five barrels, of fairly standard type. In addition, an interesting new American barrel,

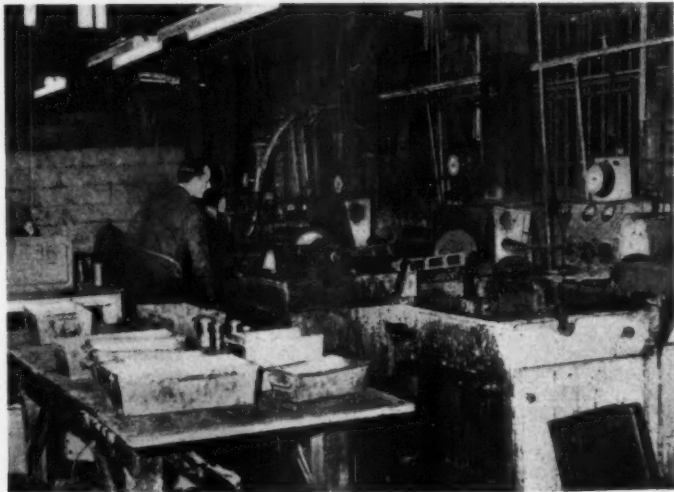


Fig. 5.—Chrome line, situated at the far end of the shop, each barrel having its own rectifier.

Fig. 6.—The Unichrome chromium plating barrel, manufactured by M. L. Alkan Ltd.

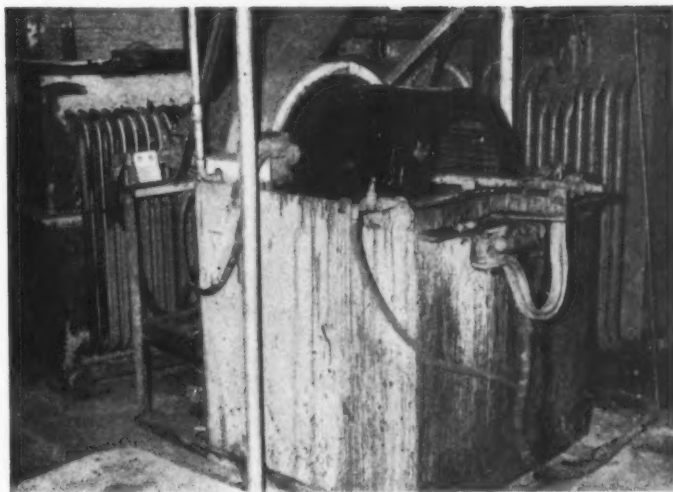


Fig. 6, which had its origin in the American industry, has been incorporated in this line, and is to be made in this country under licence by M. L. Alkan Ltd. It is designed for batch bright chromium, plating a large variety of small parts. The 180-gallon steel tank is lined with rigid P.V.C. and is equipped with a thermostatically controlled heating medium, a motorized solution stirrer and exhaust hood. The insulated steel plating cylinder 24 in. in diameter by 20 in. long, is rotated by an $\frac{1}{4}$ -h.p. motor. Two cathode liners, one of the corrugated type for cylindrical and near cylindrical work and the other a rigid type for flat work, are included with the unit, but are interchangeable with other designs. The cylinder is fitted with two discharge gates and revolves at $\frac{1}{2}$ r.p.m. Work can therefore be discharged quickly and without loss of solution into a fixed hopper. The unit plates about 5 lb. of work at a time. It is hoped that at Atlas it will enable plating to be done on larger components and some components that have hitherto defied the technique of barrelling.

Also at this end of the shop is a section very much of an experimental nature, where a small amount of barrel silver is undertaken in two small open ends. Most of the work is to specification for the electrical industry where the superior electrical properties of silver make it an ideal finish.

Other barrelling processes in this experimental section include acid tin and bright acid tin. The non-toxic properties of tin enable it to be used on domestic components, likely to come into contact with food. The acid tin is used chiefly for specification work while the bright acid tin is still very much in the experimental stage, although some commercial work is done. Again Atlas were

among the first to barrel bright acid tin, the normal method being to plate it in still vats. Up to now results have proved more than satisfactory and it is hoped that this particular process will be developed on the same scale as the many other processes.

Two other processes, both very important in their way, are tool treatment black and phosphating. The tool treatment black has many advantages where tolerances are critical and some anti-corrosive finish is required. Two high caustic solutions at different temperatures are used with a special de-watering oil bath available, following a water rinse. This oil is also used as a protection for components with a light nickel deposit and to a certain extent eliminates staining, sometimes experienced with nickel.

Barrel Polishing

The de-burring and polishing section is situated immediately in front of the experimental section and plays an important part in a shop of this nature, both as a finish and as a pre-plating operation. The section comprises two large barrels, with double compartments, two medium barrels and two midget barrels for the smaller quantities. A storage system is incorporated where the various grades of media, all of the normal type and graded according to the finish required, are kept. Granite chips and limestone chips are used for de-burring and honing and steel balls for polishing. All the barrels have an automatic time switch system which ensures that polishing times, are not exceeded even during the night when attention is not possible. The larger machines are driven by individual motors but the midget barrels are driven by a common motor.

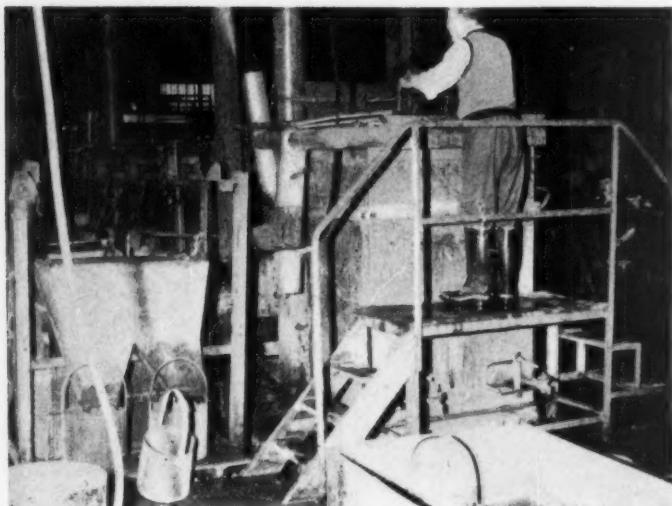


Fig. 7.—(left) An I.C.I. Trisec dryer, used where appearance is a prime consideration.

Fig. 8.—(below) A water-cooled germanium rectifier manufactured by Westinghouse Brake and Signal Co.

Drying

The drying of barrelled components is done by a varying number and makes of dryers situated at convenient points throughout the shop. Along the main gangway, earlier described as the boundary line of the two types of plating solutions, are seven centrifugal dryers all within easy reach of the various sections. One of these dryers is kept solely for drying brass work. Experience has shown, and it is not known for certain whether other shops have experienced the same, that the use of centrifugal dryers tends to affect the appearance of nickel plate. This was first noticed when the older-type sawdust dryers, now used only for drying bronzing and some barrel chrome, were replaced by more modern dryers. For this reason the company purchased an I.C.I. Trisec dryer (Fig. 7) which is used for drying nickel-plated components, where appearance is important. This technique treats the parts with trichlorethylene containing Trisec, in a liquor form instead of the usual vapour. The additive has been developed to be effective at moderate temperatures so that advantage can be taken of the low heating requirements of trichlorethylene. The effect of the additive is to displace the water film on the metal surface by the trichlorethylene, which readily evaporates. The manufacturers, say that the treatment is most effectively carried out in simple equipment, incorporating a water separator, and extra free board above the water level and fitted for rim ventilation. One compartment, the one containing Trisec, is used for drying and the other for the subsequent rinsing of the dried parts in boiling trichlorethylene. This ensures that the articles are not only perfectly dry but also quite



free from grease contamination. The whole process is completed in one minute. As with any drying process it is necessary to ensure that the work has been well rinsed in clean water before it is introduced into the plant. Atlas have found that

(Continued in page 18)

Technical Developments and Advances in NICKEL-CHROMIUM PLATING

Conclusion of Report of Recent

INSTITUTE OF METAL FINISHING SYMPOSIUM

Abstract

ACCEPTANCE REQUIREMENTS FOR NICKEL-CHROMIUM PLATING

by W. G. L. Miller *

THE author outlines the circumstances which have brought about the use of nickel/chromium plating, and shows how the motor-car manufacturer devises and amends specifications and testing methods to meet the increasingly severe conditions to which plated components are submitted in service.

A great deal of poor chromium plating, some of it very bad indeed, marred the appearance of almost-new cars. Investigation showed that the corrosive constituents of the atmosphere and of dirt thrown up from the road, in addition to attacking the basis metal through pores in the plating, were capable of corroding through the nickel itself, and that the rate of this attack was greatly accelerated by cracks or stresses in the deposit. Composite coatings employing a substantial undercoat of copper and having an excellent salt spray rating, often gave very poor service in moist SO₂ laden industrial atmospheres because of the more rapid penetration of the thinner nickel, while the presence of the copper/iron couple accelerated the attack on the basis metal once penetration had been affected.

The use of processes giving ductile semi-bright deposits, requiring only a minimum of colouring before chromium plating, enabled the change from bright nickel for bumper bars to be effected economically, while the development of crack-free chromium plating allowed substantially better coverage to be obtained without bad cracking in the high-current-density areas.

The question of plating thickness requirements in relation to service conditions, and the need for more searching tests which would reveal conditions in the plating liable to cause premature failure, were the subject of a great deal of work both in this country and in the U.S.A. These resulted

in specifications being modified to include more stringent and revealing tests, to demand specific physical properties for the plated metals, and in some cases to require a substantial increase in the thickness of the plating; the Ford Motor Company Specification P40.1960 illustrates this trend, and table from this specification are shown in the paper.

The author attributes the mass breakdown of post-war chromium plated zinc die-castings to such factors as increasingly severe service conditions, the enforced lowering of acceptance standards and spontaneous cracking of excessively brittle deposits of bright nickel, and adds that even so neither specification amendments nor improved plating techniques have been able to effect the required improvement in service life. Premature failure is likely to continue at a high rate, because of:

(a) The corrosion potential of the conventional copper/nickel/chromium plating sequence.

(b) The scope offered by the die-casting technique for the low-cost high-volume production of most intricately shaped parts which cannot be plated economically to meet minimum thickness requirements at all points on the significant surface.

(c) The predisposition to porosity of the basis metal itself.

The author briefly outlines the factors that weigh against putting into effect any system of testing or inspection to ensure every chromium plated part conforms to specification. Accelerated corrosion tests are destructive and cannot be used for production, and this also applies when determining the thickness of the nickel and chromium films. So far as these requirements of any specification are concerned, acceptance or rejection can only be based on the quality of a small percentage of incoming plated parts. Furthermore, the size and frequency of deliveries, the range and diversity of chromium plated components, and the number of different suppliers involved, combine to make it economically impossible to isolate and withhold from production each separate delivery of component until samples have been checked.

The paper then describes methods of testing used in the motor-car industry, the B.N.F. thermoelectric thickness tester and the American Magne-gage, both of which, in the authors view, possess

* Ford Motor Co. Ltd. Chassis Division).

sufficient reliability and accuracy to enable non-destructive thickness testing to be done with confidence even on a piece-inspection basis.

In conclusion, he says that the maintenance of a high standard of plating quality is essential to the well being of the motor industry and can only be assured by insistence that every plated part shall be to specification. More rapid corrosion tests and non-destructive thickness tests have afforded material assistance in increasing the chance of preventing substandard plating from being put into service, but only when the capabilities and limitations of nickel chromium plating are realized by all concerned, and parts are designed so that plating to specification is economically possible, will there be any real hope of restoring public confidence in chromium plating as a durable and lasting finish on cars.

Abstract

MEETING SPECIFICATIONS IN NICKEL-CHROMIUM PLATING

by D. Bouckley *

THE author briefly comments on the chief factors to be considered when copper-nickel-chromium plating to specification, namely racking and the shape of parts, anode to cathode distances, current-density limitations and throwing power of individual solutions.

Discussing the steadily declining use of copper as an undercoat, Mr. Bouckley observes that where it is used, the Rochelle copper has been largely replaced by high efficiency solutions having a high metal content, and the cyanide present as the potassium salt. Air agitation is used, and temperatures usually range between 130° to 150°F. This type of solution can be used without brighteners to give quite good brightness in the usual range of thicknesses. It is necessary, however, to use constant filtration through activated carbon. An excellent way of doing this is to have granulated carbon in a perforated container in series with, but placed before, the filter. To maintain a good degree of brightness and relative freedom from roughness it is essential that the carbon be changed daily, and that it should be soaked overnight in caustic soda.

Some controversy exists as to the best type of copper anode, the normal rolled fire-refined, or the as-deposited electrolytic anode. The author favours the latter. Anode area is fairly critical for best operation and will depend to some extent on the solution used. High anode current density will cause undue polarization and filming or sludging

giving rise to roughness. Low anode current density, particularly as produced by poor contacts, will cause incorrect dissolution and disintegration, again leading to roughness.

Cathode efficiency will be largely dependent on carbonate and hexavalent chromium content. The latter is a real danger, as quite small quantities can affect the efficiency. The chromium comes in, most probably, *via* jig coverings from the previous chrome plating operation. In such cases frequent dosing with sodium hydrosulphite may be essential. As for the carbonate content, some falling off in efficiency may be expected when this reaches 12 oz. per gal., although some solutions have been known to be quite serviceable up to twice that figure.

The author divides the main use of nickel solutions into semi-bright and bright. The semi-bright can be further divided into non-levelling or low levelling on the one hand and high-levelling on the other. Some bright nickels also suffer further sub-division into high chlorides or high sulphates. For any system of brighteners and addition agents, a high chloride solution will permit the use of higher current densities than a high sulphate and will probably be more tolerant to zinc contamination than the high sulphate. Against this, high chloride deposits are usually more brittle and the solutions are more costly to buy and run.

Brittleness and stress, with its exaggerated form, spontaneous stress cracking, usually go together. Some solutions particularly high chlorides, are prone to these defects, and things to look for are boric acid content and balance of brighteners.

Blistering of nickel deposits may be due to bad cleaning of the underlying surface. The author includes in this classification films picked up even after perfect cleaning, and he suggests that the cleaning sequence should always end up with an anodic alkali cleaner followed by a dip in 50 to 100 per cent hydrochloric acid, or an anodic sulphuric acid etch. Brass is preferably cleaned in a hot anodic or cathodic cleaner, followed by a 25 to 50 per cent hydrochloric acid dip, or cathodically in a cold cyanide-based cleaner, followed by a 10 per cent sulphuric acid dip. Blistering of nickel on copper plated die castings may come from bad swills, from a contaminated copper solution, or from porosity in the die casting. Stripping of the bright nickel coating in duplex nickel may come from undue delay in transferring from one bath to another; from the first coat becoming bi-polar or anodic, or from contamination of either solution. Bad contact, giving interrupted plating, is another cause of stripping.

The author makes a general comment on chromium, that thickness of deposit can be increased by increasing the current density and that maximum

* Wm. Bate Ltd.

benefit is usually obtained by increasing the temperature. He then discusses the common complaint of "white-washing," one of the many problems encountered when the new nickel and chromium solutions are used.

Chromium solutions are more tolerant to metallic contamination than nickel solutions, but their highly corrosive nature makes them liable to build up large amounts of iron, nickel, copper and zinc. It is therefore essential to remove these impurities but as a result of the strict control of effluent disposal the only reasonable method which offers itself is that of ion exchange.

The paper finally describes the corrosion resistance of nickel/chrome parts and some suggestions are offered for the successful handling of parts.

DISCUSSION

MR. PEARSON, opening the discussion on Mr. Miller's paper, said it was believed that British car manufacturers on the whole spent less money on finish than was spent on many continental cars. One German manufacturer stated last year, that the metal finishing on one of his medium-priced cars cost more than the total productive cost of the gearbox. Whether or not this extra cost was justified was perhaps debatable, but it reflected the different attitude of some continental manufacturers to the importance of finish, by accepting higher proportionate material finishing costs than was commonly done in this country. Nevertheless, efforts were continually being made to make chromium plating in this country more durable.

Before the war, Mr. Pearson's company had used the following tedious procedure for steel parts: polish steel; flash nickel, dull copper (0.001 in. approx.); mop copper; dull nickel (0.001 in. approx.); mop nickel; chromium plate; chromium finish. With modern coatings that procedure would be ruled out, but extremely few service complaints had been received when it was used. After the war, economic considerations demanded the adoption of bright nickel to reduce polishing costs, and the copper had also been eliminated. Criticisms of plating quality came in, despite the progressive increase in the thickness of the nickel. In most cases the inferior corrosion resistance was not associated with insufficient nickel, but with porosity. It was claimed that, thickness for thickness, bright nickel was equivalent to mopped matt-nickel in providing protection for the steel, but any tendency to produce porosity would seem to have a much greater detrimental effect with bright nickel than with matt nickel.

The avoidance of bright nickel on such parts as bumper bars, as mentioned in the paper, was of interest. Its reintroduction as the upper coat in a duplex nickel system suggested that the main attraction of this process was again to reduce

polishing costs rather than to achieve something extra in corrosion resistance.

At the present time it was still uncertain whether a straight single nickel would not serve equally as well as duplex. Recent work carried out by British and German investigators had shown that, thickness for thickness, polished copper plus bright nickel gave equivalent, and in some cases even better, corrosion resistance (by the SO_2 test) than duplex nickel.

The author obviously appreciated the value of the various accelerated corrosion tests now available, and it was difficult to understand why his firm relied on the straight salt-spray test, now agreed to be almost worthless, and the mild Corrodokote test which would show up only very bad deposits.

The author's list of specifications for nickel/chromium electroplates called for comment. A footnote to specification P-40, 1959, said: "The elimination of all copper plating may be made only with the specific approval of the Process Development Department and the Quality Control or Chemical Engineering Department of the affected Division."

Did this mean that the author's company still attached some importance to the value of a preliminary coat of copper before nickel on steel? It would seem that in his company there were many sections involved in the control of chromium plating in respect of both process and finished parts. This could go wrong, being a possible instance of "too many cooks." Again, referring to P-40, 1960, footnote (a) said: "If the supplier has instituted proper process and controls, initial copper plate may be replaced with nickel when approved by product engineering."

In this case some of the "cooks" appear to have been got rid of, but it would be interesting to know how product engineering could ensure that the supplier had instituted and, in particular, had maintained proper process and controls.

Tank Contamination

MR. OLLARD said that some years ago he had traced a certain amount of contamination to rubber-lined tanks. Certain suppliers of rubber linings had used accelerators in their rubber which affected the solution. Such a rubber lining could go on causing trouble for longer than might be thought. The rubber research people had supplied eight samples of the substances which were put in the rubber. Of these, two were found to be relatively harmless, but there were six which completely upset a bright nickel solution. Of those six, two or three could be got rid of with activated carbon but the rest could not. It was quite possible, therefore, to get rid of contamination in a solution and then have it introduced from a source apt to be overlooked, the rubber lining.

Mr. Bouckley had said that the automatic tank had many advantages over the operator-served tank. If one watched people loading tanks one would find that they had slightly different techniques. One man would put the article in and make contact quickly, while another would hang about and let the article remain in the tank for a short time before it was connected with the busbar. The delay might be only for a second or two, but with a bright nickel solution which was contaminated with copper during the time the article was being put in and the connections made, it was possible that there would be some deposit of copper on the surface, which would not be in the form of a monatomic layer all over the surface but of little blobs of copper, because some steel must come out for some copper to go in. That would mean starting to deposit on a heterogeneous surface, which did not do much good.

The surface on which the deposit was made was not always given sufficient attention. It was not entirely under the control of the plater.

Mr. Miller might be interested to know that the B.S.I. Committees on metal finishing were now being segregated and reorganized under their own Industry Committee, which was going to be the Industry Committee for Surface Finishing. An opportunity would be given in the near future to decide just how those Committees should be reorganized. One proposal was to set up a further Committee to see whether or not some method could be found of rating corrosion assessments. Mr. Miller would probably agree that it was most difficult to find two people who would give exactly the same rating to a corrosion specimen after it had been through a standard test, and that led to difficulty in the specifications; corrosion tests could be laid down but it was difficult to say exactly how to interpret the results. The point was not the standardizing of a test, which could be done fairly easily, but an opinion after the test had been done. There were methods by which that difficulty had been overcome in other connections, and they believed that it could be got over in this one. It was too early to give details, but such a Committee would probably be set up and it would be interesting to see whether or not it had any luck.

MR. O. JONES (Mond Nickel Company), on the subject of specifications, said he had compared Mr. Miller's specification P40, 1960, with B.S. 1224. He assumed that "exterior duty" in P40 corresponded to the severe grade in B.S.1224 and that "interior duty" (which he took to mean the interior of a motor car) could be related to the moderate service grade of the British Standard. He did not want to go into too much detail, but it was of interest to look at the first four classes in the Table on the last page of the paper. For

Class B, steel for interior duty, the copper was 0.00002 in. and the nickel 0.00030 in. B.S.1224 gave a moderate service grade figure of 0.0008 in. for nickel. For the next one, Class D, brass for interior duty, the nickel undercoat was given as 0.00010 in. Was it Mr. Miller's belief that that was enough? The B.S. figure was 0.0003 in. The third one, Class E, brass for exterior duty, was 0.0006 in. in B.S.1224, and at Dagenham it was also 0.0006 in. The fourth, white metal for interior duty, gave 0.00015 in. for copper, against 0.0003 in. in the British Standard, and 0.00025 in. for nickel, against 0.0006 in. in the British Standard.

Thickness Testing

MR. PEARSON (B.N.F.M.R.A.), said that Mr. Miller compared the B.N.F. thickness tester with the Magnegage and remarked that the B.N.F. thickness tester could be criticized on grounds of intricacy and size. The latest version of this tester was much smaller than the earlier one which Mr. Miller had seen, while as for its intricacy it consisted of an amplifier and a probe. The probe admittedly was held in a stand, but it could be hand-held and there seemed no reason why it could not be taken into the plating shop and used on the work as the work came from the line. They themselves had done this. The Magnegage, Mr. Miller said, was pocket size and hand-held, but normally it was fitted to a stand, so that it could be stand-held. The figure of ± 0.00005 in. when hand-held would be very difficult to achieve.

MR. SPRAGUE referred to Mr. Miller's paper and in the first place to what was said about the cyanide solution. He suggested that not enough emphasis was placed on the fact that what was wanted was not just brightness but levelling power, and broadly speaking he did not think that this was obtained with cyanide solution. In connection with copper solutions, reference was made in the paper to the new high-conductivity copper anode now on the market but it would be interesting to have more information about this from the suppliers, because he believed that the delay in getting it in this country had been partly a matter of the price of copper.

He emphasized the point made about preventing hexavalent chromium getting back into the solution. It was particularly bad for copper. In addition to making additions of sodium hydrosulphite in solution it was useful to soak the jig coverings when not in use in hydrosulphite solution to make sure that any hexavalent chromium which might be trapped was got out.

The author might have said more about the removal of metallic impurities by low current plating out. It was not just a question of current density or even of voltage. It was possible to

cover the range of current density very largely by using a corrugated cathode. Impurities in small quantities would not be taken out unless they came up to the cathode surface.

It was suggested that chromium plating should be conducted as a batch process, but it would seem that the process was limited in capacity and that burning would occur if one simply loaded a portion of a large batch from time to time.

The removal of boric acid was largely a question of careful control and analysis. There was some volatilization of boric acid through the air or fume and it was usually found that boric acid concentrations went down at a greater rate than fluoride, which was not involved in the cathode reaction.

Stainless Steel

MR. CLARKE (Tin Research Institute) suggested that there was another answer to the problems under consideration, apart from duplex nickel and duplex chromium, and it was the unpleasant one of stainless steel. He remembered reading some time ago that the Ford Motor Company were going to use stainless steel, and perhaps Mr. Miller could give some comparisons. It would be interesting to know what composition of stainless steel they used and what they had found about the manufacturing position, the wear on tools. Also, how did the economic position compare with plating, and had they any experience of the corrosion of stainless steel? Was it, when put out to corrode on cars, as good an answer, apart from the cost, as it was said to be, and had platers a great deal to fear from it if plating could be improved sufficiently?

MR. TAYLOR said that a nickel strike preparatory to normal plating was beneficial, especially with poorer quality steels, giving improved corrosion resistance and better covering power, but the main factor was quicker transfer time. In all practical plating shops the time factor was very important. Wood's nickel strike had advantages for certain types of work. There were organic addition agents which were liable to break down, and from that angle the covering was better if the time was not excessive and it resulted in a better subsequent deposit.

With regard to the other paper, Mr. Taylor was glad to find someone, in addition to himself, who criticized jigs. The design and manufacture of jigs left a great deal to be desired.

Surface Cleaning

For cleaning the underlying surface Mr. Bouckley mentioned 50 to 100 per cent hydrochloric acid for steel, and 25 to 50 per cent for brass. Either he was not happy about the ductility of the bright nickel or he did not trust the efficiency of his

platers. Mr. Taylor shuddered to think of the danger of acid trapping, but there he might be unduly harsh. Mr. Bouckley referred to the cathodic cleaning of brass, having already mentioned the question of chromium contamination and the use of sodium hydrosulphite. It was well known that while cathodic cleaning was valuable in itself there was a tendency to get a coating of foreign metallic material, co-deposited, with the subsequent danger of ripples. In practice anodic cleaning gave a much better job.

It was well known that bright nickel, organic, had several inherent troubles such as poorer throwing, poorer covering and high internal stress. Unless drastic steps were taken to jig the work properly, to maintain carefully the organic solution, free from metallic contamination, to give regular carbon treatment, to have freedom from iron and to keep the bulk up, peculiar results could be obtained. Again and again they were misled, by simply comparing bright nickel with another bright nickel. There should be a standard on which to base these things.

Another point which was very important was nickel passivity. With a nickel which was prone to passivity the chrome coverage could be very poor. It was not only a question of the rate at which whitewashing or passivity developed, but any breakdown product in the solution could be a major factor. He thought that they would be driven more and more to semi-bright in preference to bright nickel, because with semi-bright they got covering power, ductility, freedom from breakdown and much higher corrosion resistance. Moreover, in the shop it was possible to limit the dangers of layering in the composite nickel, because he had yet to see proof that duplex nickel was not an overlay effect and not an integration of one deposit with another.

MR. NICHOLSON commented on Mr. Miller's suggestion that the B.N.F. thickness testing meter was useful in the laboratory but not sufficiently robust for use in the works and said that they had been using several of these instruments in their works for the last eighteen months and so far not one had been damaged.

A SPEAKER expressed surprise that no reference had so far been made to the B.N.F. Coulometric method of thickness testing, which provided to his mind the only method of accurately determining chromium thickness.

Foreign Experience

A SPEAKER said that on continental cars, with one exception, straight single bright nickel was being used and duplex nickel, although it had been tested, had not so far been accepted. From this he thought it could be concluded that they had found no need for a duplex nickel system.

DR. ZENTLER-GORDON said that it was quite useless to compare continental practice in metal finishing with British or American practice, for the simple reason that the atmosphere and the degree of corrosion could not be compared. On this island, especially in winter and in industrial atmospheres such as London, Birmingham and Sheffield, outdoor corrosion tests were not comparable to those in a continental country such as Central Germany, or even in the United States away from the seaboard, or even industrial atmospheres, and the results could not be correlated and therefore the finishing practices should not be correlated.

MR. MARSHALL said that he had been informed that on the continent the chromium attachments on British cars stood up better than those on continental cars.

MR. SIBBER (South Africa), said experience showed in Cape Town, that most continental cars stood up better. In particular it was the components polished in automatic machines which failed after a few months, and sometimes even before they were put into service. The bumpers seemed to be done as a rule on automatic machines and showed what looked like scratches caused by the emery when the levelling of the nickel had not been satisfactory. The difference between the plating on British and continental cars was only marked on those components that had obviously been dealt with on automatic polishers.

AUTHORS' REPLIES

Replying to the meeting, MR. W. G. L. MILLER said that his company used the duplex metal process in certain applications to enable ductile nickel to be applied to certain parts liable to vibration, and also to overcome the very serious disability of dull nickel on parts of large area. It was well known that with piece-work the standard of polishing might tend to fall off in the interests of production. The degree of polishing might fall off in an effort to get a high piece-rate return. The net result was plating which was grossly sub-standard at certain points. Any system which could give the advantages of a fully ductile nickel and, at the same time, eliminate not merely the cost of the polishing but the danger of metal removal, would be very advantageous. Consequently, when his company had been approached by a manufacturer with the suggestion that this might be feasible they agreed, after testing. That was why they used a large amount of duplex plating. He regarded duplex as being essentially a method of applying a ductile nickel without incurring the difficulties of polishing. On one plant which they operated themselves, they had it running on a type of duplex system which in effect replaced the previous copper by an equivalent amount of nickel.

They regarded it as a very good scheme to replace the copper by ductile nickel. The service returns justified the decision to change over to duplex nickel on the particular components to which he had referred.

Reference had been made to peeling, to the danger of the separation of the two layers. With regard to that he could only say that in some hundreds of large parts which he had examined for peeling and which had been returned specifically on account of peeling, in 98 per cent of them the peeling had not been between the two layers of nickel. Provided the duplex technique was carried out in a reasonable manner, with the ordinary precautions, the danger of laminations did not exist if the correct solution had been chosen.

Polished Copper

On the question of polished copper and bright nickel *versus* duplex nickel he had no very strong feelings. In the discussion an instance had been quoted where English plating was better than European and of another area in which the European plating was better than the English. His own view was that well carried out plating of nickel on polished copper could be as good as duplex nickel, but he regarded it as being considerably less fool-proof. In one plant he had deliberately eliminated copper from the sequence even though it had meant a fairly heavy capital charge in altering automatic plating plant. He had no wish at all to condemn bright nickel on polished copper, but he preferred to replace the copper by nickel, preferably by ductile nickel.

His firm clung to the salt spray and Corrodokote tests largely because, despite the many unfavourable comments about the salt spray test, he still found it to be a very valuable test indeed giving an accurate assessment of service conditions. He was not nearly so happy about the Corrodokote test. As he had stated in the paper, they used these tests extensively, but they preferred to reject if possible on a salt-spray test, which was in very wide use, when they had to reject.

He was sorry that the question of eliminating the copper undercoat by the specific permission of certain departments had been brought up. These were in fact American specifications which had been amended to meet conditions in this country where possible. The reference there to which division was to give permission could have been changed. It had not been changed, but it was of no importance to anyone using that specification, because they would apply to his Company for permission and not to the department mentioned, even if such a department existed by that name in Great Britain. It could very well be an American designation. For instance, they used the word "superintendent" with an entirely

different meaning from the normal one in English factories. No one would deplore more than himself any system which meant having several authorities within one firm all carrying out different tests.

He would deal more thoroughly with the question of the salt spray test on stainless steel, because a number of questions had been put to him on the subject of stainless steel. On straight chromium stainless steel, unless the initial skin, which tended to be dechromized, was removed the steel would rust in ordinary dew overnight. The 48-hour salt spray was more than adequate to determine whether or not the supplier had removed the dechromized layer from the steel. Steel which passed the 48-hour test would in his opinion pass a test of 96 hours, so that there was no point in holding up delivery for four days when the result could be known in two.

Mr. Jones raised the question of the apparent complete disagreement between the P40, 1960, specification and the British Standard in regard to the thickness of nickel for moderate duty. That exposed a peculiar anomaly which it had taken his Company about 25 years to understand and act on, but he was afraid that it had taken the rest of the industry that length of time to fail to see it.

Nickel on Motor Cars

In the days of nickel-plated finish there had been three classes of thickness of plating on a motor car. There was the plating required for exterior work, which obviously had to be of sufficient thickness to withstand not merely corrosion but wear, due to polishing, abrasion and particularly that due to cleaning. Second, the interior parts not subject to weather or to blasting with road grit, parts such as control knobs and door handles, nevertheless had to withstand the wear of usage. Finally, there were parts such as ashtrays, which suffer very little wear and are protected from the weather. The metal thickness for this third category had merely to be sufficient to provide corrosion resistance without wear.

When chromium plating was introduced a very obvious fact was overlooked. The exterior parts had to have the thick nickel to withstand corrosion and for normal heavy duty, but in the interior of the car the situation was very different; the wear was not on the nickel at all but on the chromium. Whether 0.001 in. or 0.0001 in. of nickel was put on something inside the car, the point of failure was when the chromium wore through; and if in fact 0.00001 in. of chromium had been applied the chromium would not wear through within the life of the vehicle. Not merely did the wear not exist, so that the thickness of nickel formerly used was not required, but chromium-plated parts which were handled constantly were

much less subject to corrosion than those which were not handled, so that if he were to use two different thicknesses of nickel in the interior of the car, he would apply the thick nickel to ashtrays and ornaments which were never handled and the thin nickel to door handles and other parts which were. He suggested that the B.S.I. requirement was not for moderate application at all in interior use, but for light duty.

If his company could afford to pay the price for the full nickel-chrome stainless steel, and if the public did not prefer the colour of chromium to the colour of stainless steel, stainless steel would have his vote every time from the point of view of durability and from experience with screws and parts which had 15 to 20 years of duty. Stainless steel was excellent, but unfortunately it was expensive and it was generally cheaper to use chromium plate as an alternative. A cheaper material, which was competitive in many applications with chromium plating, was the straight chromium steel. He had already mentioned that if the dechromized layer was not removed the steel would corrode like a piece of boiler-plate, and would be covered with red rust all over if put out on a lawn in a summer night with the summer dew; but, if this was removed by electro-polishing (as he would prefer) or by sufficiently heavy polishing to make sure that the first thou came off, and preferably the second as well, the material seemed to be completely durable, provided it was not exposed to moisture in the absence of air. It was quite possible to corrode through a piece of this steel by dropping a small particle of iron on it and leaving it in contact with the stainless steel. It could be and was an entirely satisfactory substitute for chromium plating, but it had certain drawbacks in preparation. There was no need, however, for any panic in the metal finishing industry.

Mr. D. BOUCKLEY, referring to Mr. Ollard's reference to trouble with rubber linings, said it was possible to get rubber linings which were satisfactory for one type of nickel solution but not for another. The permanganate treatment which they had to give occasionally was not intended to deal with contamination from rubber, but there were various organic contaminants which came from the atmosphere or from breakdown of brighteners and which needed this oxidation treatment to remove them.

Mr. Sprague mentioned copper solutions and levelling power. Mr. Bouckley believed that only acid copper solution had any appreciable levelling power. They used copper less and less, mainly on such things as castings. If acid copper solutions could be shown to have appreciable levelling power they could come into use prior to nickel and

(Continued in page 18)

Atlas Plating Ltd.*(Continued from page 10)*

the process is particularly suitable for items of intricate shape where water may be lodged in recesses or held by capillary action.

The drying of the barrel chrome is carried out by two centrifugal dryers, housed in the chrome line and used solely for this purpose.

Lacquering

A small section consisting of one W. Canning and Co. Ltd., spin lacquering machine, is situated on the extreme right of the shop. The machine has a centrifugal action in which the components are dipped in the lacquer, spun, to obtain an even coating, and dried. A very fine finish, both durable as well as decorative, is obtained by this method on brass plating, barrel bronzing and bright barrel-polished components.

Rectifiers

One of the most important considerations in a plating shop is that of power supplies. Atlas have a total number of 17 rectifiers with an output in the region of 11,800 amp. Most are made by Westinghouse, and are either of the oil-immersed selenium or water-cooled germanium type (Fig. 8). In spite of the early teething troubles experienced by some platers with the germanium type, Atlas had installed in their shop one of the prototypes, and have since purchased three of the later models, in which the much publicized problem of overloading has been overcome to such an extent that it no longer exists. A cut-out switch has been incorporated so that the rectifier cannot under any circumstances be overloaded, and in fact protects it from the destructive ageing, associated with this problem on other types.

Another advantage that Atlas have found in the use of these germanium rectifiers, is a considerable saving of valuable space which has been taken up by additional barrels.

Effluent Disposal

The layout of the effluent draining system has been given much thought by the company and a two level system has been evolved in which uncomplimentary solutions are not allowed to mix under any circumstances. Recently, due to the use of a proprietary solution for stripping nickel, the presence of nickel cyanide in the effluent, rendered the normal treatment of the cyanide with hypochlorite, ineffective. In view of the severe penalties imposed by local councils, and the sometimes unknown chemical reactions that take place with some of the later plating solutions it is hoped that instead of briefly describing the disposal of effluent in this article, a separate feature will

be published about the layout and the special equipment being installed at Atlas to ensure that future effluent will not contain more than 4 to 5 parts per million of cyanide.

(To be continued)

I.M.F. Symposium Papers*(Continued from page 17)*

chromium, but he still thought that semi-bright nickel of the levelling type was probably better.

He agreed with the soaking of jigs in sodium hydrosulphite to prevent contamination of the solution. For the removal of impurities they used the corrugated cathode. It did cover a range of current density, but it was not the complete range; it was still necessary to specify an average current density, and they had found that the removal of copper or zinc was better done by altering the current density and that the corrugated cathode did not completely cover the range. It might do so if given enough time. Agitation was very important. The use of titanium was still in its infancy, but the preliminary trials so far were very encouraging. It was expensive, but where it was necessary to get, say, 0.001 in. of nickel in a recess it might be necessary to put on 0.004 in. or even more as an average and probably up to 0.006 in. at some points. It would then be well worth while to use an auxiliary anode if by so doing the average deposit could be reduced to 0.0015 in. while ensuring that the minimum of 0.001 in. was maintained, because the anode was only an initial cost whereas the cost of the extra nickel which would have to be put on, in its absence, went on all the time.

Mr. Bouckley said that with polished copper the corrosion resistance was sometimes quite good, but duplex nickel was better economically and that was the main point about it.

He had omitted to point out the advantage of high-speed chromium solutions. Possibly the speaker who referred to them had self-regulating types of solution in mind. The truth was that Mr. Bouckley's firm had used these solutions for such a long time that he had forgotten how good they were. It had been suggested that some of the difficulties of control of the solutions could be overcome by using self-regulating properties. He could not make any comparison, but there were more difficulties with the crack-free solutions.

Mr. Bouckley did not feel that there would be any undue acid retention on account of the acid cleaning treatment and he had found nothing in practice to suggest that any corrosion resulted. With regard to the cleaning of copper or brass, he had mentioned cathodic cleaning only because it was sometimes useful to avoid stains which were a little unusual.

Metal Finishing Technology

A Students' Guide: 6

An Introduction to the Examination Syllabus in Metal Finishing of the
City and Guilds of London Institute

Compiled by A. ALEXANDER

APPLIED ELECTRO-CHEMISTRY (Cont.)

Dis-similar Metals in Contact

IT will be obvious from what has been said that if two different metals are placed in contact with one another and they are both also in contact with a solution containing suitable ions, then a current will flow between them returning through the solution. Thus one metal will become anode and the other cathode, the atoms leaving the surface of the anodic metal and passing into the solution, while metal ions from the solution will deposit out on to the cathode metal. Under these circumstances, therefore, one metal will corrode while the other will not.

Metals may be arranged in a series according to the potential which is set up between the metal and a solution containing the metal ions, usually a normal solution, that is a solution containing one equivalent weight in grammes of the ions per litre. The series of metals arranged in this way (Table 1) is called the "electro-chemical series." In this country we usually put metals like aluminium and zinc at the top of the list and gold and precious metals at the bottom and we show the potentials in gradually increasing numbers, those at the top being negative and those at the bottom of the list being positive, hydrogen being taken as zero. While hydrogen is of course not a metal, one can produce a so called hydrogen electrode by saturating spongy platinum electrodes with hydrogen gas

and this produces a potential in exactly the same way as a piece of metal immersed in a suitable solution.

The actual potential of course can only be measured in relation to some other electrode and it is usual to measure them against a calomel electrode which is actually a mercury electrode containing a paste of mercury and calomel (mercurous chloride) immersed in a potassium chloride solution saturated with calomel. However, it is usual to express potentials not against a calomel electrode but against a normal hydrogen electrode, that is a platinum electrode saturated with hydrogen immersed in a solution containing one gram of hydrogen ions per litre. As one cannot actually set up such an electrode because it is not possible to weigh out the hydrogen ions and place them in the solution, it is more convenient to use a calomel electrode and allow for the difference in potential which has been calculated to assess what the potential of the hydrogen electrode would be.

If we then take two metals, let us say zinc and copper, and put them in contact in a solution of sodium chloride, since copper is at the bottom end of the table and zinc at the top, a potential will be set up between them and a current will flow (Fig. 1). In point of fact, electrons will pass from the zinc to the copper so that there will be an increased concentration of these at the interface between the copper and the solution and a decreased concentration at the interface between the zinc and the solution. Since decreasing the amount of electrons in the surface atom of the zinc will allow these atoms to escape from the surface and enter the solution, the zinc will dissolve. At the copper/solution interface, sodium ions will congregate and capture electrons from the copper surface and become sodium atoms. However, metallic sodium in an aqueous solution would be attacked by water, and so, in fact, these atoms will react with the water to produce sodium hydroxide and hydrogen.

The sum total of this reaction will be that the zinc will be dissolved whereas the copper will not

Table 1

Metal	Potential against normal Hydrogen Electrode
Magnesium	-1.86
Zinc	-0.76
Iron	-0.44
Cadmium	-0.39
Cobalt	-0.29
Nickel	-0.22
Tin	-0.14
Lead	-0.13
Hydrogen	0.00
Copper	+0.34
Mercury	+0.79
Silver	+0.80

be attacked, at any rate for some distance from the point between the two metals. Thus we have the state of affairs where on the one hand the zinc will protect the copper while on the other, the copper will cause the zinc to corrode more rapidly than it would do by itself.

This reaction is extremely important in electroplating because we are normally putting a thin coating of one metal on to another. If the coating is not completely continuous, and in practice it usually is not, then reactions of this kind will be set up at local spots of discontinuity.

For example, let us take a piece of iron and plate this with a coating of zinc. Let us suppose then that the coating becomes scratched or otherwise removed at one or two spots. We then have a system similar to that described above. Zinc comes above iron in the electro-chemical series and will therefore dissolve in preference to the iron so that we do not find any rust spots but the zinc is gradually dissolved away. After a time of course, when a large area of the zinc is removed, the underlying metal will start to rust but the coating will give good protection for some time.

Now let us suppose that instead of plating the iron with zinc, we plate it with copper which comes below the iron in the table. In this case the iron will dissolve in preference to the copper and if there is a small discontinuity in the surface it will immediately start to dissolve at this point. Since the amount of iron exposed is small but the amount of copper is large, there will be a relatively large current from the copper to the iron and the iron will dissolve very quickly, much more quickly than it would if it had not been copper plated and so a pit will be formed in the iron and a considerable amount of rust deposited on the copper plating round about.

It will be obvious from the above, therefore, that when plating an iron article with zinc it does not matter very much if the deposit is slightly porous, if it is being plated with a metal which comes below it in the electro-chemical series, *e.g.* copper or nickel, it is most important that the plated coating should be continuous and free from any discontinuities, otherwise you will be tending to accelerate the corrosion rather than prevent it.

At this point it must be pointed out, however, that the electro-chemical series as published is an ideal series and metals do not always behave under all circumstances as this might suggest, *e.g.* if one measures the relative potentials of iron and cadmium, one would place iron above cadmium, that is to say the potential is more negative. However, in point of fact, it usually behaves the other way round under most normal conditions and cadmium will protect iron in the same way that zinc does although the potential between the two is less. The actual areas of the two metals involved, the

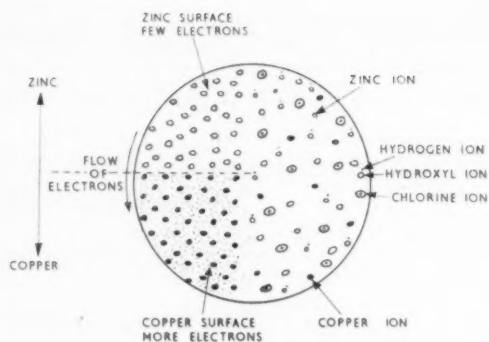


Fig. 1

solution in which they are immersed and the physical conditions under which they are placed, will all alter the potentials to some extent and may, under certain circumstances reverse their order. However, the general principles apply and should be borne in mind.

It is possible to use this principle to protect metals by affixing blocks of zinc or magnesium on to steel structures immersed in water. Sometimes large blocks of zinc are bolted on to steel hulls of boats.

The zinc dissolves slowly, producing a small potential on the steel surface which protects it against corrosion. Pipe lines have also been protected in this way or, alternatively, one can protect them by using a source of electric current connected to an electrode near the pipe and passing a current from the electrode to the pipe so as to make the pipe the cathode.

It is desirable that the student should form an actual mental picture of what is happening in these cases. As previously mentioned, any description given here is somewhat oversimplified and in point of fact the whole system is an extremely complicated one. However, it is hoped that what has been said will give some kind of mental picture which will serve to explain the observed reactions. In forming this picture one must remember that the electron, as already mentioned, is considered to be a unit of negative electricity and the stream of electrons actually move in the opposite direction to that which is conventionally ascribed to the electric current. Thus if we pass a current between two sheets of metal across an electrolyte we think of it as passing from the anode to the cathode and depositing the metal on the cathode or negative electrode. In point of fact, however, it is really going the other way, the electrons entering the solution at the cathode and leaving it at the anode. This is apt to be confusing and has arisen because, at the time when the direction of the current was

first described electrons had not been discovered and it seemed more obvious to think of the current as passing from the electrode, which dissolved, to the electrode on which metal was deposited and carrying the metal with it.

This assumption is generally used in elementary lectures, it being suggested that the metal ions are carried through the solution by the electric current. Actually the ions do migrate under the influence of the applied potential but they do so quite slowly and it is doubtful whether this actual migration is very much affected on ordinary commercial processes except perhaps in the thin layers of electrolyte near the electrodes.

For the most part the ions are carried through a solution by diffusion since they tend to diffuse through the solution by virtue of their own movement and that of the atoms of the solution in question, and also by convection, that is the actual movement of the solution itself.

If we consider a cell, let us say for example two sheets of copper immersed in a saturated solution of copper sulphate, and if we pass a current from one sheet to another through the solution, then the copper will be dissolved from the anode and will deposit on the cathode. Near the surface of the anode, copper ions will be entering the solution and this will increase the density of the solution at this point so that it will tend to fall to the bottom of the cell. Near the surface of the cathode on the other hand, copper ions are being deposited out of the solution and this layer of solution will get lighter and tend to rise. The result of these two actions will be to set up a circulation of solution in the cell, the solution falling at the face of the anode, passing across the bottom of the cell, rising at the cathode and passing back again near the surface and in fact this can be observed experimentally. In this way copper ions are carried from the anode to the cathode.

In commercial plating solutions we generally find that this method is rather too slow. It is usually preferred to stir these solutions in some way, either by mechanical paddles or by blowing air through them or by some other convenient method. This assists in carrying the ions across the solution so that it is possible to speed up the process.

We will consider an article being plated in a commercial vat. This article will be hung on the cathode bar, that is to say when the current is turned on, a stream of electrons will be passed into it and these may be regarded as passing to the metal-solution interface and there producing an increased concentration of electrons in the atomic lattice of the article concerned.

The article will therefore tend to attract metal ions to the surface and these metal ions, on receiving additional electrons from the surface, will become neutralized forming atoms. Now these atoms will

no longer be free to move through the solution but will tend to take up a position on the surface of the metal. Exactly how they do this, however, is still a controversial matter but the position they take up is obviously extremely important from the point of view of obtaining the desired results. A good deal of excellent work has been done on this matter and a number of theories produced. It seems probable that immediately after the discharge of the ion the atom so formed may still be free to move somewhat so as to take up a position in the surface lattice of the metal. All these small particles have a somewhat human trait in that they will generally take the path of least resistance, that is to say go the way which is the least trouble. If an atom therefore is released at a metal surface, it will take up a position which requires the least energy to get to. It is quite obviously desirable that these atoms should form a smooth continuous lattice producing regular crystals without discontinuities, etc. On the other hand, the conditions under which they are released may make a considerable amount of difference. If they are released slowly and steadily they are much more likely to take up such a position than if a large number of them are released suddenly together.

One can imagine one of these atoms in the solution very close to the metal surface. This metal surface, as we have already seen, will be composed of a lattice work of atoms and it may be there are some vacant sites in this lattice where the atom can go and thus become part of an already existing crystal. On the other hand all these vacant sites may be full or there may be other atoms of a different kind present which upsets the lattice structure. Under such circumstances the atom may find it easier to start a crystal of its own than to take up a position in one of the existing crystals and it may set off with one or two other atoms to form another lattice of different orientation. This is more likely to happen if a large number of atoms are released together at a relatively high speed.

In practice we find therefore that if we increase the current density of the metal surface, that is to say if we pump in the electrons faster and so release the atoms more quickly, we generally tend to get smaller crystals, the atoms having a greater tendency to form new crystals than to take up a position in one of the old ones. Alternatively, if we put in to the solution some other type of atom or molecule which will tend to be deposited on or adsorbed on the metal surface, this will tend to prevent the metal atoms taking up a position in the existing lattice and they will generally form new crystals again giving a finer crystal structure. This is the basis of those substances which we generally call "addition agents" which are used for refining the crystal structure of the deposited metal.

We have said that there is perhaps more chance of getting large regular crystals if we deposit the metal slowly on the surface. However, in commercial practice we generally wish to deposit the metal as quickly as possible. If we increase the current density the metal will deposit more quickly and, as mentioned above, we shall probably somewhat reduce the size of the crystal which again may be beneficial in certain cases. However, if we continue to increase the current density we shall soon reach a point where there are insufficient metal ions in the layer of the solution adjacent to the metal surface to take up all the electrons which are being pumped into this surface. The potential between the metal surface and the solution will therefore become more negative and after a time, hydrogen ions—always present in the solution—will be released together with the metal ions. These will tend generally to upset the structure of the deposited metal and produce a powdery deposit often called in the trade a "burnt" deposit. Such a deposit is, of course, quite useless for ordinary purposes. If we wish therefore to speed up a deposit process it is necessary to arrange for a sufficient quantity of ions of the metal to be present at the metal interface. We have mentioned that these ions are carried across the solution, not by the action of the current itself to any large extent, but mainly by diffusion and convection.

Obviously we want to carry them across our plating vat as quickly as possible otherwise we shall get a dense solution around the anodes and a solution containing very few metal ions at the cathode. One of the best ways of course of getting the metal ions across the solution is to stir the solution which will then tend to keep the concentration of ions constant in all parts of it. However, one cannot bring any large quantity of ions right up to the metal surface in this way because it is difficult to stir a solution near the surface since one gets the effect of "skin friction" and the ions, when they get near the surface, probably move more as a result of diffusion than convection. The speed at which an ion will diffuse is largely a matter of the temperature of the solution and of course the size of the ion. As mentioned before, when we increase the temperature, the movement of the various atoms increases and therefore there is a bigger tendency for the ion to diffuse. Also due to this movement the viscosity of the solution is reduced so that the ions can be attracted more easily by the potential of the metal surface. It will be seen therefore that in order to work a process as fast as possible we need to keep the solution agitated and to work it at as high a temperature as is convenient. Also quite obviously we want to dissolve as much metal salt in the solution as we can so that the actual concentration of the metal ions in the bulk of the solution will be as high as

possible. In fact, in commercial practice, a large number of solutions are worked hot especially where we are concerned with maximum speed. The temperature, however, at which we work the solution must often be governed by the nature of the solution itself because some solutions, *e.g.* cyanide, tend to break down if we heat them too much. However, the above picture is put forward to illustrate the general idea of agitation and heat but, as mentioned before, all these word pictures have to be somewhat over-simplified and this must be remembered when dealing with individual cases.

We have spoken of the potentials between the metal surface and the electrolyte. When the system is at rest this potential is more or less a measure of the tendency of the metal either to go into the solution, or to be deposited out of the solution. If we take an electrolytic cell, for example, two sheets of copper in a copper sulphate solution and apply a very small potential across the two electrodes, we shall find that after perhaps a small initial jump, no current flows through the system. If we gradually raise the potential there will come a time when current starts to flow and this will happen at a definite potential depending on the system and physical conditions. The potential between the solution and the electrode under these circumstances is described as the "liberation" potential of the ion concerned and under such circumstances is specific for any particular metal. If we put a number of metal ions together in a solution and gradually raise the potential we shall find those metals which are at the bottom of the electro-chemical series tend to deposit out first and as we raise the potential they will gradually come out in the order of the series or, at any rate, in that order which would prevail under the particular conditions. The actual potential required, however, will depend on the concentration of the metal ions in the surface layer and the nature of the ion and other conditions. If we take a mixture of copper and zinc sulphate and pass a current through this, between two platinum plates, we shall find that we shall deposit out only the copper because this tends to deposit out first and not until practically all the copper has been deposited shall we obtain any zinc. When all the copper is deposited the cathode potential will become more negative and zinc will start to deposit out. On the other hand, if we take a mixture of copper and zinc cyanide we find that the conditions are quite different. Under these circumstances complex ions are formed in the solution, metal cyanide being dissolved in sodium cyanide and since a concentration of copper and zinc ions in the cathode layer is then extremely small, their "liberation" potentials approach one another. If we chose the conditions correctly we may therefore be able to deposit the two metals simultaneously

and in fact we do get a deposit of brass having a crystal structure very similar to that of ordinary cast brass.

It might be argued from what has been previously said that if a concentration of the copper and zinc ions is so small we would either have to work at an extremely low current density or, alternatively, that we should get a great deal of hydrogen liberated. In point of fact we do get a certain amount of gassing but although the concentration of the metal ions as such may be very small, there will be reservoirs present in the form of a complex sodium cyanide ion. As soon therefore as the metal ions have deposited out of the cathode layer they are replaced by others formed by breaking up of the complexed ions themselves and it is therefore possible to work this solution at a reasonable speed.

The actual nature of the complex ions formed in cyanide solutions is again a matter on which a good deal of experimental work has been done, and on which there has been a good deal of controversy. It is not proposed to discuss this at this point but merely to describe the general mechanism by which it is believed these solutions function.

Action of Brightness

When we were discussing the deposits of the metal on to the cathode layer we said that various substances which could be adsorbed on to this layer might affect the deposit.

If we take a substance like gelatine and dip a piece of metal into a solution of this we shall find, on withdrawing the metal, that there is a very thin layer of gelatine left on the surface. This layer may be only one molecule thick and it adheres quite tightly to the surface and is difficult to remove. You cannot, of course, see it but its presence can be proved by various tests, *e.g.* a further layer of metal deposited on it will not adhere. A layer of this type is said to be adsorbed on to the surface, that means it goes to the surface and sticks there being bound to the surface by forces of the same nature although probably not as great as that by which a metal atom would be held there.

A number of organic substances can be adsorbed on to metal surfaces. These organic molecules are built up of a number of atoms, in some cases quite a large number. They are therefore very much larger than the metal atom and if one of these molecules gets on to the cathode and remains there it is quite obvious that it will interfere with the growth of a crystal which is being deposited.

The exact method by which these materials function is still a matter of some doubt but it can be shown that the majority of the brighteners

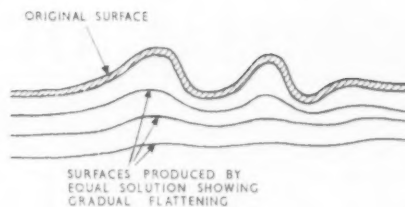


Fig. 2

used today to form bright fine-grain deposits will be adsorbed on to the metal surface and incorporated into the deposit. Organic molecules of this type do themselves migrate under the influence of an electronic potential and this again probably helps to bring them up to the cathode surface. It is possible by various methods of test to find out the points in an irregular surface at which the greatest concentration of these materials is present in the deposit and it has been found that the highest concentration is usually at the outstanding point on the cathode surface. Thus, if we have a rough surface composed of say prominent and recessed portions we may imagine that the organic molecules will tend to congregate at the prominent parts of the surface and will form greater interference there with the depositing process so that the recessed portions of the surface tend to receive the deposits preferentially and thus produce a more even smooth and bright surface (Fig. 2).

It has been suggested that the configuration of these molecules tend to "fit" on to the lattice structure of the metal being deposited, possibly depositing themselves preferentially on one crystal face rather than another. At the present moment there has not been a great deal of experimental evidence published of this but it is a possible hypothesis. It may be that in this way some of these materials are able to affect the orientation of the crystals in the deposit favouring the growth of certain crystal planes as against others and those producing an oriented deposit in which the majority of crystals are lying in the same plane. At the present moment, however, as mentioned above there is little experimental evidence but the general picture of how these addition agents work should be borne in mind. It is fairly obvious from this picture that the concentration must be very carefully controlled, as one usually finds in practice, because if there is too great a concentration of the organic matter it may certainly interfere with the deposit and produce a rough streaky result. It is also obvious, of course, that the material used must be compatible with the materials from which the solution is composed.

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DISPOSAL OF WASTE FROM METAL- TREATMENT PLANTS

Report of Congress on Industrial Effluent
held in Milan

THE disposal of waste is one very important aspect of all metal-treatment plant, and discussion of this problem, undertaken in Milan at the first congress on industrial effluent, was of particular interest owing to the participation of several well-known scientists and technicians.

Surface treatments such as pickling, chromium and nickel plating involve the eventual disposal of water charged with cyanides, chromates and various metallic salts and the purification of this waste becomes a problem of the utmost importance to all producers in view of the strict regulations that are being issued with regard to pollution.

At the conference, M. Bouchard dealt with the purification of solutions of alkaline cyanides and acid chromates. At the moment two methods are available, namely the process which enables the purified water to be recovered or not. The former method makes use of classical chemical methods, while the latter is based on the use of ion-exchange resins. The purely chemical methods have the advantage of low cost and working space but the disadvantages that:

- (a) the treated water cannot be used;
- (b) since the dosage of the reagents is made under conditions of constant delivery, the process is only applicable to liquids that do not present important variations in delivery or concentration.

Ion-exchange resins, on the other hand, offer the advantages that besides recovering the water, they do not require reagent dosing operations and that the volume of liquid treated is reduced.

M. Bellobono dealt with the use of ion-exchange resins in the treatment of waste from galvanizing plants. He said that up till now, the methods of treatment employed are essentially of a chemical nature and include, neutralizing processes for acid and alkalis, reducing processes for chromates, chlorodizing processes for cyanides and so on. Often however, and particularly in the electro-deposition of noble metals, the type of recovery required is not always easily handled by purely chemical methods. As a result a number of new

methods based on the application of ion-exchange resins were introduced and studied, particularly in the fields of anodizing, chromium-plating and the pickling of copper-based alloys.

Ion exchange is not an economic method of treating waste unless the valuable metal salts are recovered. The scarcity of chromic acid during the second world war prompted the study and use of ion exchange resins for the recovery of chromates. The introduction of non-oxidizable cation exchangers of the sulphonic type, such as Amberlite IR 120, Permutit Q and Dowex 50 gave a conclusive contribution. R. L. Costa said that he foresaw the use of these resins for the regeneration of chromium plating baths.

Besides the cation exchange for chromium-plating baths, it is possible to recover chromic acid from the electrolytes of anodic oxidation, by removing the chromate ion by anion exchange, producing a solution of sodium chromate. The excess alkali and sodium chromate are passed through cation exchange resins in order to block the sodium ions and leave chromic acid in the effluent.

Solutions of the acid can then be neutralized at an appropriate concentration. Finally, it is possible to combine these methods to give mixed solutions of pure and impure chromic acid. In spite of some limitations regarding the concentration of chromic acid in the solutions to be treated and the temperatures that the resins can withstand, the ion-exchange process must be considered as a useful alternative when comparison is made with the expensive method of chemical destruction of cyanides.

Another interesting and important aspect of the electrolyte method of purifying and waste treatment is represented by the ion-exchange process concerning alkaline cyanides and complex metallic cyanides, in particular, copper, silver and gold.

In the field of effluents from galvanizing lines, the ion-exchange process has all the characteristics that enable it to compete with the more classic

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cyanide destruction treatments owing to the possibility of recovering valuable metals and purifying alkaline cyanide solutions.

M. Bellobono re-examined some aspects of the purification of alkaline cyanide electrolyte discharges, comparing the various processes and taking into account layouts that enable the cyanides to be recovered and neutralized in the same plant.

From existing data and from specially devised tests, he concluded that purification of the diluted waste containing cyanides or complex cyanides is possible by the use of anion exchange resins of basic character or by coupling cation exchange resins of the sulphonic type with quaternary-group anion-exchange resins. The percentage of recovery is usually higher than 90 per cent. A comparison of these methods shows that the coupling of cation and anion cycles leads to effluents with a negligible content of metallic ions and to more highly concentrated solutions due to the high affinity of cation and anion exchange resins for hydrogen and hydroxide ions respectively. Alternatively, the anion-exchange system is useful in the selective separation of copper or other ions, such as nickel or zinc, from the solutions containing silver and gold or in the direct recovery of complex cyanides under this form.

M. De Negri examined the problem of waste disposal in galvanizing and chromium plating plants. Generally the waste is made up of washing water and zinc-containing pickling residues and is usually acidic. The waste from chromium plating plants presents an interesting problem since it has a higher poisonous potential owing to the presence of cyanide. In this case it is imperative to protect the zones into which the material is discharged, making more obvious the problems aroused by using a slow dispersion and an empiric process.

The point was raised by a firm engaged in pickling, galvanizing and chromium plating, where the discharge of waste was divided into three fundamental groups, containing respectively NaCN , $\text{ZnCl}_2 + \text{HCl}$ and H_2SO_4 , CrO_3 and Cr_2O_3 .

The treatment problem was first solved from the theoretical approach and the results of experimental tests transferred to industrial processes. The effluent containing cyanide must be treated separately to transform the cyanogenous groups into carbonates and nitrogen oxides. The operation requires an alkaline ambient to avoid the volatilization of the deadly HCN . The waste containing CrO_3 must be subjected to a preliminary reduction in order to bring chromium to its lowest valency; the operation can be carried out in an acid ambient for example by the addition of NaHSO_3 . The re-united chromium and zinc containing waste must then be subjected to a neutralization process planned to coincide with a

stage designed to allow the formation of sludges containing chromium and zinc as hydrates.

The final design of the plant is very simple and includes three distinct sections for the reduction of the chromates, the neutralization of the acids and the decantation and general clarification.

The first section is handled by a tank of rectangular section, equipped with a mechanical stirrer to ensure rapid diffusion of the reagents tending to make the mass homogeneous. The reagents (namely H_2SO_4 , and NaHSO_3) are prepared separately and fed by a dosing pump.

The neutralization of the acids takes place in a second and larger unit that receives the waste from the galvanizing plant and the products from the first stage of the installation. Calcium hydroxide is gravity fed in the required quantity for neutralization and quantitative precipitation of the zinc, chromium and other heavy cations.

From the second unit the reduced and neutralized liquid with the precipitates maintained in suspension is passed to a dynamic decanter, where it is joined by the products resulting from the destruction of the cyanides. The whirling motion of the fluids from the first section then becomes laminar and ascensional, allowing a flocculation which determines the separation of the precipitates and the eventual clarification of the water.

INSTITUTE OF METAL FINISHING Ninth Annual General Meeting

THE Ninth Annual General Meeting of the Institute of Metal Finishing was held at the Cafe Royal, London on Monday, December 5 last, with the president, Mr. A. A. B. Harvey, in the chair. Following approval of the minutes of the previous A.G.M. the president conveyed the apologies of the hon. treasurer for his inability to attend and the accounts were presented by Dr. S. Wernick, hon. secretary, who read to the meeting a statement prepared by the treasurer. The accounts showed that after transferring the sum of £1000 to the House Fund, the Institute had a balance of over £400 excess of income over expenditure, which was an improvement over the position in previous years, reflecting largely the changes in publishing procedure which the Institute had adopted.

The Annual Report of the Council, reviewed the achievements and events of the past year. In spite of the increase in membership subscriptions, recruitment was continuing at a reasonable rate.

Following the formal business the Westinghouse prize was presented to Mr. S. C. Britton and Mr. M. Clarke and the Johnson Matthey Medal to Mr. Ralph H. Atkinson in absentia.

INSTITUTE of VITREOUS ENAMELLERS

Annual Conference, Birmingham, 1960

A Report of the Second Technical Session

Abstract

THE INFLUENCE OF WATER VAPOUR UPON THE ADHER- ENCE REACTIONS BETWEEN GROUND COAT AND SHEET IRON

by L. Merker*

THE paper deals with a series of experiments comparing the effect of various controlled furnace atmospheres on adherence. As a quantitative measure of adherence, an attempt was first made to evaluate the intensity of the light scattered perpendicular from the de-enamelled metal surface, but this was unsuccessful. Bending tests showed, nevertheless, a strong dependance upon the firing conditions. It was found that the only way to show the dependance of enamel on firing conditions was to embed the specimens in thermoplastic resin and to prepare microscopic cross-sections of the enamelled piece by grinding and polishing. The change in adherence could then be examined by comparing the picture of the corroded metal-enamel interface.

From the experimental results arises the question how the mechanism of adherence in an oxygen-free atmosphere can be explained. According to A. Dietzel, two basic reactions are necessary for the formation and further working of a local galvanic cell, which then brings about corrosion and adherence. The first is a precipitation reaction due to the more noble behaviour of cobalt. The second is a depolarization reaction taking place in the following manner: cobalt metal transfers the valence electrons received from iron to more electron-seeking substances such as the molecular oxygen of ferric ions Fe^{3+} . Only by this latter reaction is the continuance of corrosion maintained.

Numerous investigations have established that the oxidation of iron in an atmosphere of water vapour results only in the formation of FeO and only in some cases are traces of Fe_3O_4 formed. The explanation why there is still adherence under those conditions lies in the nature of the compound FeO . In particular, Engell has found that the compound FeO , which is not a stoichiometric one, has, at 900°C ., a composition range between $\text{Fe}_{0.946}\text{O}$ and $\text{Fe}_{0.883}\text{O}$. Also from his investigations it can be seen that at any temperature of interest in enamelling, there is always a shortage of ferrous ions Fe^{2+} within the compound FeO , and therefore for charge neutrality an equivalent amount of ferric ions Fe^{3+} must be present in the FeO lattice.

The author concludes his paper by saying that:

- (1) The adherence reactions between ground coat and sheet iron can take place in a wet furnace atmosphere containing no free oxygen.
- (2) The adherence is proportional to the partial pressure of water vapour if oxygen is absent.
- (3) There is not necessarily a relationship between poor adherence and formation of hydrogen defects.

DISCUSSION

THE CHAIRMAN (Dr. B. K. Niklewski) said the problem of the adherence of enamel to iron had been explained by a number of authors and many theories had been put forward.

A good appearance of the ground coat and cover coat could be achieved by re-enamelling. If the ground coat was removed and then re-enamelled, results were still excellent. This had been done by many people and no cobalt was necessary. The appearance of the enamel coating by the physical attachment of the enamel to the rough surface of the iron was very good. In certain atmospheric conditions, however, corrosion occurred. If the molten enamel were applied,

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without the use of cobalt, nickel or air, and if there were a certain amount of water vapour, corrosion might occur, due to an electric charge or some other cause.

DR. MERKER, speaking of the re-enamelled surface mentioned by the Chairman, asked if the ground coat taken off was a cobalt one.

THE CHAIRMAN said that it was a normal ground coat. After it left the de-enamelling plant a white enamel was sprayed on, the appearance of which was good; probably, there were traces of the old groundcoat left on the metal after de-enamelling. The cover coat was also of good appearance.

MR. N. S. C. MILLAR said microscopic examination indicated that when titanium white was applied direct to metal, needles were formed at the enamel-metal interface. These needles were probably rutile. He asked if these rutile needles or dendrites had any bearing on the adhesion of the enamel to the metal.

DR. MERKER remarked that from a temperature of 450° C. a composition of ferrous oxides would lead to the formation of needles of metallic iron.

MR. A. W. MURDOCH added that the same adherence could be achieved with an antimony or a zircon enamel, but the needles did not occur; at least, he had not detected them there.

MR. S. E. A. RYDER said that, from experiments he had made, he did not think the formation of needles or dendrites influenced the adhesion. They occurred in ground coats and in titanium cover coats.

THE CHAIRMAN referred to a very fine, plain metallic component used in America for a small radio component, and said that minute needles grew on the surface of the metal, about 0.001 in. long. This was enough to cause a short circuit in this component, which is used now for guided missiles.

MR. RYDER said the needles that Mr. Millar had mentioned were very short, about 0.0005 in. He believed that when using titanium enamel, they were in the enamel itself.

DR. MERKER said that, if over-fired, oxide needles would be found throughout the enamel.

Complicating Question of Adherence

MR. RYDER replied that these were not the kind of needles to which Mr. Millar and himself had referred.

He could not help feeling that the question of adherence was being made more complicated than was necessary. Very often it was explained purely on mechanical grounds, that the enamel flowed into a rough surface. A factor which might need more explanation was the role of the nickel.

THE CHAIRMAN said he was well aware of the many theories advanced to explain the mechanism

of adherence. Mr. Ryder had put forward a good idea, but it was still the action on the surface of the metal by the molten enamel.

It is known that the presence of oxygen does help in the etching; and the presence of water would help. It seemed that for good enamelling a deeply etched surface was extremely important.

MR. RYDER agreed that the type of etching was most important.

Surface Tension of Enamel

THE CHAIRMAN added that another very important factor was the surface tension of the enamel in contact with the iron; the presence of cobalt or nickel changed the surface tension so that the enamel could take advantage of the deep etching and go down into the iron.

DR. MERKER commented that the influence of a metal oxide on surface tension had been neglected. When the oxide was dissolved from the metal by the enamel there was no place for a hold. The reaction of the nickel or cobalt at the metal surface was different, forming local cells. The main purpose of the theory was to explain how the facial corrosion or facial etching was achieved. The etching was not regular; there were localized holes and part of the metal remained practically unetched.

THE CHAIRMAN said there was a theory similar to that of the formation of local electrolytic cells; by the local action between dissimilar metals or the iron oxide, resulting in an electrical discharge.

DR. MERKER mentioned the case of a copper screw embedded in an iron sheet and left in the open, whereby the corrosion of the copper screw was very much enhanced.

He did not mean to infer that in all cases the electrolytic theory must apply, since the adherence of ground coats and cover coats on cast iron was not related to electrolytic corrosion.

MR. RYDER asked if Dr. Merker thought that it was not mechanical action that eventually held the enamel to the sheet iron.

DR. MERKER said that in every case it was mechanical.

MR. RYDER said it was now known that a rough surface could be obtained without pickling.

Abstract

EVALUATION OF ALUMINIUM ENAMELS

by A. W. Brace*

THE selection of suitable grades of aluminium and its pretreatment prior to enamelling are briefly discussed and tests for spalling, acid re-

*Aluminium Laboratories Ltd

sistance, abrasion resistance, alkali resistance and resistance to boiling, described. The tests show many of the complex variables which need investigation in developing satisfactory enamels and enamelling technique. The main purpose of this paper has been to record the techniques used and to attempt to study in isolation from other factors the effect of change in one processing factor. To illustrate these problems various commercial frits have been examined and data recorded. It must be remembered that these results apply to the particular formulation and processing conditions used and other values might well be recorded for commercially prepared frits.

It is reasonable, however, to conclude from these tests that the users should bear in mind that each frit has its own characteristics and should be fully explored before using them in production. A frit may require firing within a limited time and temperature range to obtain its optimum properties, another one may have a wider working tolerance but at the sacrifice of some other property, such as gloss or acid resistance.

There is a fair indication that the Schuh and Kern test is a useful method for investigating abrasion resistance, since not only does each frit appear to have its characteristic range of abrasion resistance but there also appears to be some relation between degree of firing and abrasion resistance, and the author considers that it may be of interest to investigate this test further. Scratch resistance has shown some surprising results and it would be desirable to investigate other mar-resistance tests before drawing any conclusions on the effect of colouring oxide on mar resistance.

The paper has not presented data which would enable results of spall tests, acid resistance and sulphur dioxide-humidity tests to be correlated with weathering behaviour. It is unfortunate that weathering tests require a considerable period before useful results can be recorded. Weathering tests are in progress but these have not reached the point where useful conclusions can be drawn.

Abstract

THE PRACTICAL ASPECTS OF ENAMELLING ALUMINIUM

*by A. H. Symonds**

THE paper discusses the potential offered by aluminium as a base for vitreous enamel. A wider range of colour is available than with other enamels and the non-rusting properties of the metal enable liberties to be taken with the metal which would not be possible with enamelled steel. The existence of the oxide film on aluminium strengthened and thickened with heat treatment

plays an important part in the adherence of vitreous enamel to aluminium.

Some complication has arisen about the type of aluminium to use and this has been further complicated by American recommendations relating to compositions which are not duplicated in this paper. Generally, the group known as NS3 is satisfactory for most work but various brands will have different qualities and it is strongly recommended that both the supplier of the metal and the frit, be contacted before proceeding with the work.

Considerable experience has now been gained in the manufacture of enamel frits and reliability is being associated with the development of frits with good resistance to solubility and easy working. The development of leadless frits has helped in operating enamel shops by ridding them of elaborate controls. Increased opacity and durability is the subject of continuous research.

The paper then describes in some detail the various mill additions required for this type of enamelling and pre-enamelling cleaning processes are also discussed.

The author also suggests that the enamel should be sprayed wet in two thin coats, particularly on intricate shapes, since it is easier to recover thin coatings with another coat. The enamel should be fired damp to lessen metal reaction and tearing, although dry enamel will fire satisfactorily. He goes on to say that firing should be carried out until the enamel reaches full maturity and if there is any doubt, test-pieces should be fired for different lengths of time until it is certain that the enamel is completely matured.

The author concludes, that vitreous enamel provides a coating offering a vast range of colours which are permanent and highly resistant to corrosion and solution, in a range of textures from glossy to matt.

DISCUSSION

MR. STOKES said that in the papers there was reference to a considerable amount of research concerning the effect of drying time on acid permeability or acid solubility. The acid permeability decreased with drying time up to a maximum of half an hour, after that the curve tended to flatten out. Referring to a statement by Mr. Symonds that the material should be pre-fired, he asked if that applied only to certain alloys.

MR. BRACE said that in his company's works enamelling was carried out as quickly as possible after spraying.

On the question of pre-firing, he thought Mr. Symonds would not mind him saying that the art or science of enamelling aluminium was sufficiently new for differences of opinion to arise. From

* Ferro Enamels Ltd.

experience of cleaning and degreasing aluminium, generally one would say that it was preferable to use some treatment such as mild etching; he would always recommend a cleaning treatment which involved some etching.

He felt that most enamellers would prefer to omit pre-firing as much as possible. At his works it was always insisted that the desmudging treatment followed pre-etching. In the United States he had met several people who preferred to dip in a cold chromic-sulphuric mixture. A neutralizing solution gave a very thin oxide film which helped to do the job which resulted from pre-firing.

It was usually found necessary to pre-fire after chromic treatment. His company were doing some further work in which they were changing from the chromic bath to another, which was not altogether dis-similar.

Necessity for Spall Test

MR. J. H. GRAY asked why the spall test was necessary, and what happened if, having finished a job, 90 hours later the test showed failure. He mentioned a case where very serious spalling had occurred on panels after they were affixed to a building, and said that this suggested that the spall test was not 100 per cent effective.

MR. A. W. MURDOCH, commenting on the question concerning the firing of the enamels, said that in the two plants he had seen, one of which was engaged wholly in enamelling aluminium and the other only partially, they were firing wet.

In one instance he was told that when spalling occurred it was attributed directly to under-firing of the enamel. He understood that since then, the spall test, where a test-piece was put through with the ware and was tested in the laboratory, had been abandoned because the test results did not correspond with experience in the field. Instead, they used an actual panel or other enamelled part and, using the same solution assessed it for spalling; he understood that this method was giving more satisfactory results.

MR. SYMONDS remarked that if the test-pieces spalled, the work would not be released; normally they would be enamelled and tested ahead of the production enamelling. Primarily the test-pieces would be designed to test the metal that was used; it was most important that the metal should be tested in relation to the particular enamel and the colour that was used. If, for instance, a matt finish was required, or some other special feature, it could have an effect on spalling. The tests must be made in conjunction, with the correct mill addition and everything else.

MR. BRACE said that with the spall test his organization had experienced difficulty in getting really satisfactory correlation. He showed a scratch

test specimen and said that this approach gave better results.

As to the period of the spall test, he said that first he made the research approach and in some cases had even continued the test for the full 96 hours in order to see what happened. But for production purposes he thought that in the majority of cases the 24-hour test would prove to be adequate.

Another point in regard to the spall test was to ensure that everything was starting off well. If a check was made that the frit formulation was right and everything was working well, the test gave the assurance that consistent results were being obtained.

On the question of wet firing, he said it was his experience that, in the continuous production of parts, using a multi-spray system, the ware could be passed straight through into the furnace.

Prevention of Spalling

MR. PORTER invited the authors to elaborate on their ideas about the prevention of spalling.

Discussing the film that formed on the aluminium and the adhesion of the enamel to the metal, he said Mr. Brace had mentioned chromate oxide conversion solution. He asked if the chromate solutions were the most suitable or whether it was possible to use other mixtures, such as phosphates and chlorides.

On the question of the heat treatment of aluminium to give the oxide film, he asked if it were applied to the pure metal or to the alloys.

Next, he said not much was known about the nature of the bond and it appeared to be a matter worthy of more research; perhaps there was a need for some work on single crystals of alumina, for example.

Finally, he recalled a reference by Mr. Symonds to some trouble that was experienced with enamelled aluminium. The metal had been treated, but it was concluded that the trouble was due to some small discontinuities in the metal.

MR. SYMONDS, dealing with the last point first, said that the work was done, not by himself, but by his colleagues in the laboratory, so that he could not take credit for it. Potassium was used first. Sodium was not so good as potassium, the latter being a vital flux. It was not easy to put potassium into the frit; that method did not give the same effect.

He said he did not know much more about conversion chromate. The way in which Mr. Porter had put his question about that led him to think that he had in mind an anodic film. He could only say that they were quite useless, for the enamel came off so quickly, almost before it could be got out of the furnace.

With regard to pre-firing, he said the aluminium, when received by the enameller, had an oxide film

on its surface. Mr. Brace thought it was a good thing to take that off. Mr. Symonds said that the enamel probably adhered to the metal just as well without the oxide film; but the film had a lot to do with the metal reaction. If the oxide film were not there, there would be a reaction in the form of bubbles, blisters, and so on.

MR. BRACE, dealing with the question concerning chromate solutions, said he presumed Mr. Porter was referring to the proprietary ones. Experience of them in his organization had not been very happy.

Commenting on Mr. Symonds' remarks on the oxide film, he said he did not believe that the aluminium oxide was appreciably soluble in the frit. The point was that by having a thin coating of oxide, particularly if there was silicate in the mill addition, it was enough to put off the metal attack until the fusing reaction occurred. He was sure that the nature of the bond was not connected with the presence of a lot of aluminium oxide.

Durability of Aluminium Enamels

MR. M. C. PATRICK said the general durability of the aluminium enamels was considered to be satisfactory, but in respect of alkali resistance levels there was an opinion that they could not be so good as the enamels used on iron. He asked if the authors could give an indication of the comparison or, alternatively, whether work had been done on the basic durability of the aluminium enamels.

MR. BRACE pointed out that aluminium enamels were still very new and it would be difficult to assess the durability in service until we had had 10 or 20 years experience of them. He could only say that on buildings in the United States they had been used for facing for 10 years and they were still looking quite good. The tests in his laboratories had extended over about three years only and they indicated that, by and large, the behaviour of enamelled aluminium was quite satisfactory. He considered that they compared quite favourably with the general run of enamels.

He shared Mr. Patrick's feeling that the approach should be cautious. He wondered if the aluminium enamels would be quite as good as others ultimately but so far the position was encouraging.

MR. SYMONDS added that before the acid resistance of the aluminium enamels was compared with that of steel enamels, a comparison should be made with other materials which might be used in similar situations. He agreed that it should not be assumed that, because aluminium was vitreous enamelled, it was not so good as steel enamel. He felt that the resistant finish of aluminium enamel could be compared very favourably with that of many other materials which were in use for buildings, and so on.

MR. A. W. MURDOCH said the other point with regard to durability, was the surface hardness of these enamels. They had to be fired at a much lower temperature than the steel enamels; otherwise they were comparable. He added that it was up to the aluminium manufacturers to make aluminium which would withstand 100° higher temperature than at present.

MR. SYMONDS remarked that then it would not be aluminium!

THE CHAIRMAN said it was known how good the steel enamels were because they had been in use for such a long time. Enamelled aluminium alloy had not been available quite so long, but it had been proved that it would last for at least 10 years.

MR. WHITE, referring to ash trays, bowls and other small aluminium articles, enamelled in attractive colours, asked if the enamellers when asked to apply some form of decoration, perhaps a name or some other device, the aluminium would have to be re-fired. He raised the question as to whether the aluminium enamels would withstand re-firing without spalling or some other trouble arising. At his works they had actually applied a transfer to some specimens, and the enamel face had spalled rather badly.

MR. SYMONDS replied that the makers had started a line of transfers on these products, and the results were very promising indeed. The success of the process depended to some extent on how the job was done. One of the problems was in the cooling.

MR. BRACE said that in his laboratories a number of tests had been made on such products and it was found that the success or otherwise of the re-firing was partly a question of technique. If tests were made on similar flat pieces of enamelled aluminium, as distinct from shaped pieces, and if the same procedure was followed in each case, the number of times the enamel could be re-fired without trouble, seemed to depend on the strength of the alloy used. In other words, on the NS 3 alloy it was most difficult to apply a number of coatings. There was another alloy which behaved a little better, but the manganese alloy was the best. At the laboratories re-firing had been done as many as a dozen times. It was partly a question of design and partly of choice of material. There was also the question of temperature and its effect on cleaning and re-enamelling.

MR. SYMONDS, having ascertained that the thickness of the metal in the specimens which Mr. White had re-fired was about $\frac{1}{8}$ in., said that in his experience the process, still in its early stages, was promising.

MR. BRACE asked if the metal was a cooker aluminium or a commercial alloy.

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Metal Finishing Technology: A Students' Guide

(Continued from page 23)

Effect of Other Organic Matter

It is well known that many plating solutions, particularly nickel, are susceptible to contamination by unwanted organic material. In fact it is probable that most of the trouble experienced in commercial plating is due to this. Very small quantities of such materials, *e.g.* resins extracted from wood, grease from faulty cleaning, materials extracted from the anode bags and other similar substances, can cause a considerable amount of trouble. The molecules of these materials become dispersed in the solution or in some cases small particles consisting of aggregates of molecules may be present. These finally become adsorbed on the cathode surface and upset the structure on the deposit usually forming pits or nodules or, in some cases, producing highly stressed deposits. When this occurs it is of course necessary to adopt some method of removing these materials which may often be difficult if the solution also contains organic materials added intentionally such as brighteners and sometimes it is necessary to remove the whole lot and remake the solution, which is quite an expensive matter. It is obvious therefore why it is necessary to take every precaution against the entry of unwanted substances into the solution. If, however, action is taken it may be possible to work the material out as, of course, it is incorporated in the deposit or it may be necessary to adsorb it by passing the solution over activated charcoal. In the extreme case one has to employ either a reducing or an oxidizing agent followed by an adsorption process.

Internal Stresses in Deposits

Most deposits of metal are found to be stressed. If we take a strip of spring steel, stop off one side, and form an adhesive deposit of nickel from an ordinary solution on the other, we shall find that the strip bends round the nickel being on the concave side. This is because the nickel deposited on the surface is in a state of tension. The actual tension can be measured in the case described above by measuring the amount of deflection and calculating the stress from the thickness of deposit and the steel strip.

It will be found that this tension will vary with the conditions of deposition, it generally being found that a bright fine-grained deposit will have a greater tension than a coarsely crystalline matt deposit. The exact cause of this tension is again a matter of some controversy; the addition of

certain materials to the solution may either increase or reduce it and in some cases it is possible by adding certain organic materials to alter it so that the nickel is in a state of compression.

A great deal of work has been done on this but the exact reason for these observed effects is still a matter of some doubt. One may imagine, however, that if we consider two adjacent crystals these may grow independently of one another for some time leaving a small space between them. When they reach a certain size the attraction between the two may be sufficient to pull them together closing the space and producing a tension in the crystals. Thus the finer the grain of the deposit, the more crystals there are in a given space and the greater the tension we might expect to obtain. It is unlikely that this is the full explanation but it may be used to produce some type of picture of what is happening, at any rate it may be remembered that the majority of metals, when being deposited under most conditions, do have these stresses incorporated in them. The metal may be either in tension or compression depending on the metal in question and the conditions of deposition, thus if one makes a non-adhesive deposit of metal on a flat surface and strips it off, one will usually find that it tends to curl although in cases where this is objectionable it is possible to overcome the trouble by varying the conditions of deposition as already mentioned.

The tension in deposits produced in this way may be quite large and in certain operations where thick deposits are being formed on machine parts which may be highly stressed as, for example, in an aero engine, this effect may have to be taken into account. In many cases the stress can be relieved by heat treatment.

(Series to be continued)

Institute of Vitreous Enamellers Annual Conference

(Continued from page 30)

MR. WHITE said he did not know, but he imagined it was similar to that used for producing the enamelled dishes, etc.

MR. BRACE added that some people had used pure aluminium, and he thought that much depended on the material used. But re-firing could be done.

THE CHAIRMAN referred to some designs which carried as many as five coats of enamel. They were of strong shape and would resist bending.

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Incomparably the fastest and most economical way to put a fully bright nickel-plate finish on brass is to team up PHOSBRITE 183 and PLUSBRITE nickel. PHOSBRITE 183 chemically polishes brass quickly—even the most intricate shapes—providing a level surface which does not require further mechanical polishing.

In the plating bath PLUSBRITE nickel addition agents provide a good colour, fully bright, highly ductile level finish at a low cost.

The PHOSBRITE-PLUSBRITE process has typical applications in instrument bezels, torch-switches, gaslighters, refrigerator trim, items for the kitchen and T.V. aerials. It offers cost savings and steadier production where brass has to be nickel-plated in large quantities.

FINISHING

NEWS REVIEW

VITREOUS ENAMEL FACING
A CHALLENGEV.E.D.C. Chairman Suggests Campaign to Fight
Competitive Materials

A PLEA for the vitreous enamel industry to unite in a powerful campaign to fight competition from other materials was made by Mr. S. W. Vickery, chairman of the Vitreous Enamel Development Council, at the annual meeting in London, on December 16. He pointed out that at the moment the vitreous-enamel industry in Great Britain was facing a challenge in the development of competitive materials and while vitreous-enamelled products were still vastly superior to all others for a great number of purposes, this challenge would require all the up-to-date methods of publicity to

match those being used by competitors, in order to retain the industry's markets. Individual efforts in this campaign may, at worst, be wasted and the only chance of success lay in uniting as an industry to face the threat; in this respect, the V.E.D.C., formed in 1956, was doing a useful job and its publicity and promotional campaign, added Mr. Vickery, deserved the support of the industry as a whole in order that it could be intensified. Plans for 1961, to be made known shortly, include the sponsoring of a new vitreous enamel symbol.

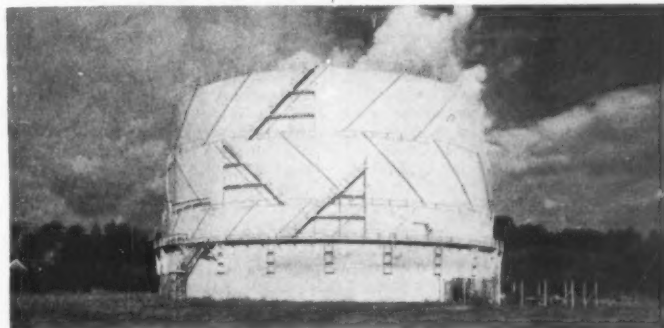
TITANIUM OXIDE PLANT
TO PRODUCE

10,000 TONS ANNUALLY

LAPORTE Industries Ltd. have made an agreement with the Western Australian government for the establishment of a new titanium oxide plant to cost £3½ million (£A4 million) at Bunbury, 115 miles south of Perth, which is expected to start production in 1964 and will have a production capacity of 10,000 tons per year. The plant is sited near sources of the main raw material, ilmenite, and Laporte have been granted port and harbour facilities, water supplies, housing and a building site.

Mr. P. D. O'Brian, chairman and managing director of Laporte Industries, has stated that the company has great confidence in the future sale of titanium oxide as a pigment for a variety of purposes and it was recently announced that they were taking a 15 per cent. interest in a joint venture with American Potash and Chemical Corporation to manufacture titanium oxide in California; Laporte is also expending £3½ million on the expansion of its oxide plant at Stallingborough near Grimsby.

General view of gasholder finished in epoxy-resin paint

EPOXY RESIN
FINISH FOR NORTH
THAMES GASHOLDER

THE first British gasholder to be treated completely with an epoxy resin finish has just been painted with Jensen and Nicholson Ltd's 'EPILAC.' This is the North Thames Gas Board's gasholder at Maidenhead, Berks.

'EPILAC,' evolved by Jensen and Nicholson's chemists, is characterized by a very stable molecular structure and is notable for its toughness, adhesion and resistance to heat and chemicals. It is claimed to give a very high degree of protection to gasholders for a long period. Moreover, when the gasholder is deflated, the oil film with which the paint is covered can then be removed more easily than when normal type steel-work paints are used.

The colour selected for the Maidenhead holder is Light Admiralty Grey (British Standard No. 697).

ATLAS ACQUIRE SUBSIDIARY

ATLAS Plating Works Ltd., has taken over the old-established business of Thomas Try Ltd., Cambridge Works, Hanwell, London, W.7. The company will operate as a wholly-owned subsidiary of Atlas, trading under their own name.

Mr. D. G. Silcock, chairman and managing director of Atlas, takes over from Mr. Lovelock, chairman and managing director of Thomas Try Ltd. Old friends of Mr. Lovelock will be interested to note that he

will continue to be with the company in a consultant capacity. Mr. J. D. Greenwood who has been manager of the hard chromium department at Atlas, joins the board of Thomas Try Ltd. The company specializes in heavy depositions of nickel, copper and hard chromium. Mr. Lovelock evolved the process of building up with heavy nickel deposits in 1916 and this has been continuously applied since that time.

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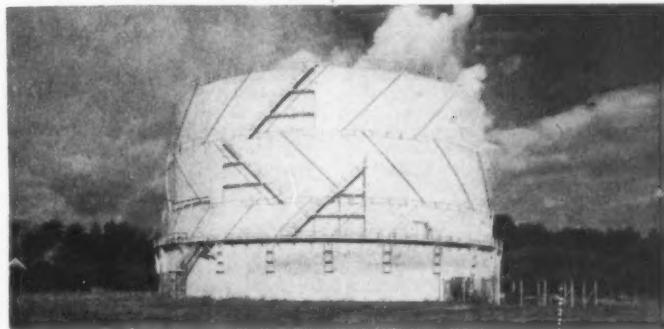
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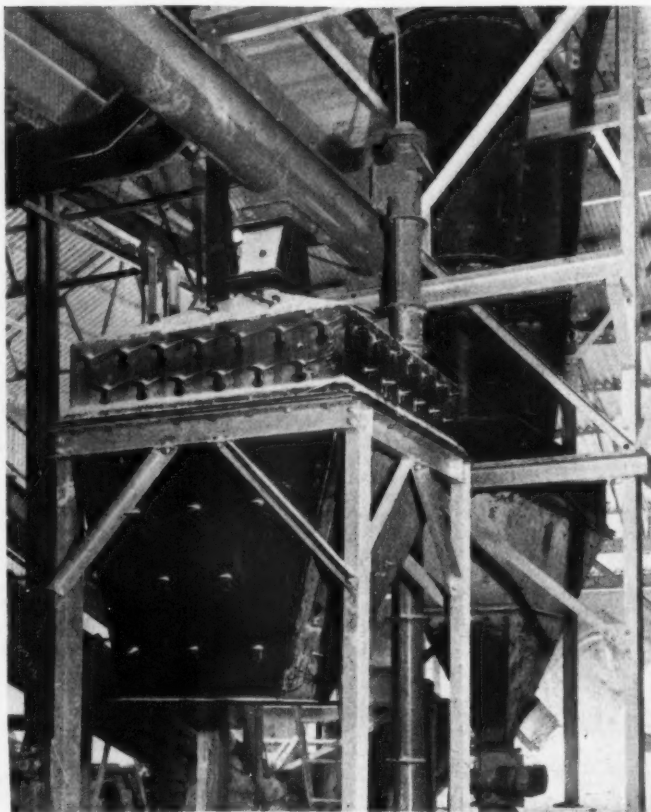
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P.V.C. CHIMNEY LINING CUTS MAINTENANCE COSTS

WATTS Blake and Bearne Ltd., Newton Abbot, have recently had the cyclone chimney and hopper of their china clay pulverizing and drying machine lined in corrosive-resistant PVC paste produced by British Geon Ltd., Devonshire House, Piccadilly, London, W.1. Dehydrated particles of clay are forced into the chimney by a blast of hot air, and collect there before being released into the hopper for packing. Besides the corrosive effect of sulphur trioxide fumes, the chimney has to withstand attack by clay particles—any erosion of the unprotected chimney would contaminate the clay with metal particles.

Natural rubber lining was previously tried, but had to be abandoned because of poor ageing properties. "Vylastic" paste, based on Geon PVC, does not suffer from this disadvantage and provides a coating with excellent corrosive- and abrasion-resistant properties, and good adherence to the substrate metal. At the same time, PVC coating has cut costs: not only is it intrinsically cheaper than rubber lining, but as both internal and external surfaces are coated, Watts Blake and Bearne expect to avoid the need for lagging the chimney, thus achieving a double saving. This was previously necessary to ensure that the temperature inside the chimney did not reach dew point before clay could be packed.

The ducting carrying the dried clay to the cyclone chimney is also PVC lined. Coating was carried out by Plastic Coatings Ltd., Guildford, Surrey.



THE cyclone chimney and hopper of this china clay pulverization and drying machine have been lined on both surfaces with Geon PVC produced by British Geon Ltd., Devonshire House, Piccadilly, London, W.1., to prevent corrosion, resist abrasion of the metal, and protect the clay from metallic contamination. The plant is at the works of Watts Blake and Bearne Ltd., of Newton Abbott and the coating was carried out by Plastic Coatings Ltd., Guildford, Surrey.

GELLED PRIMERS REDUCE LABOUR COSTS

A SUBSTANTIAL saving in time and labour costs of protecting structural steelwork from corrosion has been developed by John S. Craig and Co. Ltd., Shieldhall, Glasgow. Thick film gelled primers, two coats of which are equal to four or five coats of conventional paints but which do not sag or "curtain" after application, were introduced by the Craig company at the Scottish Industries Exhibition in September, 1959, after extensive laboratory and raft tests. At that time, the products were primarily developed for the marine market and sea trials conducted over the past year have been so successful that this has led to the development of their performance

for use on industrial structures, subject to severe corrosive conditions but inaccessible except during process shut-down. Several high steel supporting structures for tanks and water coolers at Colvilles' Dalzell works were coated with the gelled primers during the works shut-down in July of last year and application properties were found to be satisfactory, allowing recoating either wet on wet, or at 24-hour intervals. Inspections to date show that durability is excellent even in the most severe exposed conditions such as cascades of hot water, or water mist combined with sulphur containing smokes from adjacent furnace stacks.

NEW TYPE ANNEALING FURNACE

A CORROSION-INHIBITING process for motor-car bright trim has been developed by the United States General Electric Co. to overcome the problem which has long troubled steel producers in the production of type 430 stainless steel where finished batches vary widely in quality. Tests have shown that the corrosion resistance of type 430 stainless steel can be greatly increased when the steel is annealed in a newly-developed high-production vertical bright-annealing furnace; all samples from this process pass the automobile industry's acid test for trim steel, which consists of dropping sodium ferric chloride on them to determine their corrosion resistance.

NECKAR WATER SOFTENER CONTRACTS

AMONG the recent contracts made by the Neckar Water Softener Co. Ltd., of Artillery House, Artillery Row, London, S.W.1, are the following major orders:

Greaves Cotton and Co. Ltd., Madras, India, placed by Clarke, Chapman and Co. Ltd., for a deionization plant of 2,500 gal. capacity consisting of a weakly-acidic cation exchanger, a de-gasser, and a mixed bed polishing unit.

Multi-stage deionization plant for the Steel Company of Wales Ltd., having a capacity of 20,000 gal. per hour, with ultimate extension to 40,000 gal. per hour.

Low pressure dosage by pump with automatic control to treat 6,000 gal. per hour and phosphate injection for four water tube boilers working at a pressure of 250 lb. per sq. in. for Reed Board Mills (Colthrop) Ltd.

Twin mixed bed deionization plants having a capacity of 10,000 gal. per hour and 240,000 gal. between regenerations, together with low and high pressure dosing for boiler feed, for the Usutu Pulp Co. Ltd., Swaziland.

Acid and melamine handling, mixing, storage and circulating plant, circulating load 200 gal. per hour, for Wiggins, Teape and Co. Ltd., Glory Hill, High Wycombe, Bucks.

Milk of lime/soda ash plant with anthracite pressure filter for pre-treatment of boiler feed water at the Stalemead depot of the Express Dairy Co. (London) Ltd.

BOARD OF TRADE TO INCREASE TRADE MARK FEES

THE Board of Trade announce that as from May 1, 1961, higher fees will be charged for applications and registrations, and also in respect of trade marks due for renewal on or after that date.

These fees have remained unchanged since 1955 despite considerable increases in administrative costs. Before any changes are made an opportunity will be afforded for anyone to make representations against the increased fees. Copies of the draft rules introducing the new fees may be obtained from the Sale Branch, Patent Office, 25 Southampton Buildings, Chancery Lane, London, W.C.2, or from H.M. Stationery Office, Kingsway, London, W.C.2, and branches, price 3d. (by post 5d.).

FIBRE-GLASS BOATS TO BE BUILT IN BRITAIN

WOODMET Ltd., of Globe Lane, Dukinfield, Cheshire, manufacturers of Woodmet trays and trolleys and specialists in anodizing and colour dyeing and general engineers, have entered into an agreement with an American boat building company to manufacture pleasure boats for the British market.

The company, American Marc Inc., of Inglewood, California, are one of the leading pleasure boat builders in the United States and manufacture wood and fibre-glass inboard, outboard and sailing vessels from 14 to 30 ft. in length.

American Marc Inc. also manufacture air and water cooled diesel engines, natural gas engines, generator sets, permanent magnet generators and precision controls.

Mr. J. Derek Irlam, a director of Woodmet Ltd., stated that at the outset his company would concentrate on manufacturing two of the most popular of the range of American Marc craft, the Catamarine, a 16 ft. six passenger fibre-glass boat ideal for water ski-ing, family cruising and competition racing, and the Baroda, a 14 ft. fibre-glass vessel fast enough for water ski-ing, yet ideal for leisurely family cruising or trolling. Other types would follow later.

Production is expected to start almost immediately. Woodmet Ltd. exhibited both the Catamarine and the Baroda at the 1961 International Boat Show held at Earls Court from January 4 to 14.

COURSES IN WORKS STUDY

THE School of Works Study Ltd., 11 Burlington Street, London, W.1, which was founded in 1951, has added two new courses to its programme to be run periodically throughout the year. Course "F" is a ten weeks course, designed to prepare candidates to take their place in an existing work study team and places heavy emphasis on work measurement, including advanced techniques. Three weeks of the course are spent in host factories under supervision; the fee is 150 guineas. Course "G" trains existing work study personnel who are destined for promotion as section leaders. Tests, revision and advanced techniques are taught; the course lasts two weeks and costs 50 guineas. The first of course "F" commences Feb. 6 and the first of course "G" on March 20.

AMERICAN ABRASIVE COMPANY EXPAND IN IRELAND

LARGE expansion plans were recently announced by the American firm of Behr-Manning Ltd. who produce 30,000 different types of industrial abrasives in a factory at Castlereagh on the outskirts of Belfast. The premises they have occupied since 1953 consist of 90,000 sq. ft. of government factory, and the new proposals will increase their production space by a total of 49,000 sq. ft. and their administration space by 6,000 sq. ft. The labour force, when the extensions are complete, will total 320, of whom two-thirds will be men. The parent firm is the Norton Company of Worcester, Massachusetts, U.S.A. Behr-Manning export a wide variety of industrial abrasives such as grinding wheels, coated abrasives, bands, belts, discs, sheets, cones, etc., which perform planing and smoothing operations using various minerals, including sapphires and garnets, to Great Britain, Europe, and a large part of the world.

DISTILLERS COMPANY GIVE INDUSTRIAL SAFETY POSTER AWARDS

THE final judging in the annual Safety Poster Competition held by the Distillers Co. Ltd., took place in London recently when three entries were chosen for reproduction and use throughout. The competition, whose subject was "Better House-keeping" was open to the 12,000 employees in the D.C.L. industrial works, yeast factories and gin distilleries in England and Wales. Preliminary judging took place at 14 regional centres and the final selection was made from the 42 local prize-winners by a panel headed by Sir George Barnett, consultant to the company on safety matters, assisted by representatives of the D.C.L. Central Personnel, Safety, Productivity and Publicity Departments. The prizewinners were: First, Mr. T. Dunn, Senior Technical Assistant, D.C.L. Chemical Division, Carshalton (£20), Second, Mr. S. G. Jones, Main Stores Department, British Resin Products Ltd., Barry, Glam. (£10), Mr. A. Gallagher, Clerk, Central Order Section, The Distillers Co. (Biochemicals) Ltd., Speke, Liverpool (£5).

Trade and Technical Publications

The first issue of the "Technical Bulletin" produced by Engelhard Industries, Baker Platinum Division, 52 High Holborn, W.C.1, contains an article on "Catalysts for Acetylene Removal from Gas Streams" and another on "Developments on High Temperature Thermocouples using Noble Metals." In a section dealing with abstracts of selected U.S. patents, there is a sub-section dealing with electroplating and surface coating. A leaflet also issued by Engelhard Industries—"Atomex Immersion Gold Solution"—describes the process of applying a thin coating of pure gold to nickel, copper and other materials. When the process was first introduced two years ago, the greatest deposit obtainable on copper was 0.7 mg./in.², but by varying the temperature, it is now possible to obtain a deposit of 3 mg./in.²

"Wiggin Nickel Alloys," No. 58, issued free by Henry Wiggin and Co. Ltd., Thames House, Millbank, London, S.W.1, describes, *inter alia*, how the Pittsburgh Steel Co. at Warren, Ohio, has overcome the problem of corrosion of the heating elements in the pickling tanks of their electrolytic plating lines by the use of Ni-onel metal. An article is also included on the use of Monel metal chain for pickling plant. Wiggin Nickel have also produced a new edition of "Theoretical Weights of Wiggin high-Nickel Alloys," Publication 1054 A, designed to assist in the calculation of approximate weights of high-nickel alloys in their various mill forms.

Bulletin 501, a four-page illustrated technical article freely available from the Chromalloy Corporation, 171 Western Highway, West Nyack, New York, details the effects of chromalizing gas turbine vanes to protect them from damage caused by high operating temperatures.

Volpsray, Ltd., Grosvenor Gardens House, London, S.W.1, have issued a leaflet describing their Volpsray "Six" spray-painting plant. The new model is much smaller and lighter than the previous model and has the same high rate of efficiency. It is available with a 1-h.p. electric motor (ball tearing type) or a 4-stroke petrol engine.

Griffin and George Ltd., Ealing Road, Alpertown, Middlesex, the laboratory furnishers, have completed their current price list of volumetric and lampblown glassware and copies can be obtained free of charge from any of the group's regional offices. The catalogue (P.2121) comprises 60 pages profusely illustrated with a wide range of glassware, including pipettes, burettes, flasks, butyrometers, Soxhlet extractors and viscometers.

The latest "Technical Data Sheets" issued by Croda Ltd., Cowick Hall, Snaith, Goole, Yorkshire, include "Proil Oily Film Rust Preventive," "Tylac Rust Prevention Varnish," "Cropeel Plastic Coating," "Croda Strippable Plastic Coating" and "Crodafluid 90/40 Oil-type Rust Preventive." Proil and Crodafluid are anti-corrosive agents for short-term inter-process purposes; Tylac is a quick-drying material for long-term protection against corrosion, abrasion and scuffing, and is suitable for agricultural implements, etc.; Crocell is a non-inflammable plastic based rubber-like anti-corrosion preparation and transport packaging material; and Cropeel is a tough, abrasion resistant and anti-corrosion vinyl plastic film suitable for long term protection of chromium plated and other highly polished surfaces from abrasion, scuff marks and marring.

A 15-page brochure issued free by the S.S. White Industrial Division, Dept. P, 10 East 40th Street, New York, 16, N.Y., provides detailed information on improved cutting techniques, applications, performance charts and new cutting powders using the "Airbrasive" cutting tool. This unit employs a controlled high-speed stream of abrasive particles and propellant gases to cut or abrade hard brittle materials such as germanium, silicon, mica, glass, fragile crystals and ceramics.

A recent issue of "Cellon Bulletin" issued by Cellon Ltd., of Kingston-on-Thames, Surrey, contains an article on melamine finishes for furniture and a description of the finishing processes at English Electric, Stratford. Cellon Ltd. have also recently produced a comprehensive booklet on the airless spray method of application which can be obtained from their publicity department.

The Purchasing Officers Association, Wardrobe Court, 146a, Queen Victoria Street, London, E.C.4, have revised the booklet "Conditions of Purchase" as a result of an approach from the Federation of British Industries since in some of the instances of conditions they were in disagreement. The title of the booklet has been changed to "Terms and Conditions of Contract" to reflect the wider use which it is now hoped will be made of the conditions. Copies are available from the secretary of the Association, price 5/-.

Borax Consolidated Ltd., Borax House, Carlisle Place, London, S.W.1, have issued a revised edition of the book "Vitroous Enamels," (the first edition of which appeared in 1949), to embrace the developments in technology which have occurred during the last ten years, such as the introduction of titania and zirconia opacified frits and other advancements including architectural applications and the use of low temperature enamels.

Roto-Finish Record, No. 6, issued by Roto-Finish Ltd., 39 Park Street, London, W.1, contains an article on a new model vibra-finishing machine and another on the use of Grisam, a process for the simultaneous cleaning and phosphating of metal surfaces prior to painting.

The Nobel Division of the Imperial Chemical Industries Ltd., Stevenston, Ayrshire, Scotland, offer a twelve-page booklet describing the structure and properties of silicones; the last eight pages are devoted to a list of I.C.I. silicone products and a summary of their applications.

"Tube-in-Strip", a 17-page brochure produced jointly by the Metals Division of Imperial Chemical Industries and the Imperial Aluminium Co. Ltd. and issued by the Publicity Department of the Imperial Chemical Industries Ltd., Millbank, London, S.W.1, deals with a material which provides tubular passageways within a sheet or strip of non-ferrous metal. Before casting the metal, rods of inert material are located in the mould and remain in the metal during the rolling process. Tubes of circular, oval or similar cross-section are produced by applying hydraulic or pneumatic pressure internally. Applications of the material are mostly associated with heat transfer, cooling operations, and multiple pipelines for liquid or gas transmission.



TECHNICAL BOOKSHELF



Metallic Corrosion Inhibitors. I. N. Putilova, S. A. Balezin and V. P. Barannik; translated from the Russian by G. Ryback; edited by E. Bishop. 1960. Pergamon Press. 196 pp. 63s.

To the purist, the title "Metallic Corrosion Inhibitors" is capable of two interpretations. Although anyone who has anything at all to do with the prevention of metallic corrosion knows that it refers to corrosion inhibitors for metals, our purist friend is still entitled to say that he thought it referred to a vast new field opened up by the Russians, namely that of metallic corrosion inhibitors for preventing corrosion.

You may consider this a moot point and if so let me hasten to add that this book does deal with the whole and now quite extensive range of corrosion inhibitors (largely organic) for metals. Nevertheless, it does serve to illustrate the care which is necessary when translating specialized technical information from one language to another. Further, unless the translator is familiar with the subject he can easily fall into the trap of inventing words which are literal translations of the original for which, however, well established terms already exist. This translation by G. Ryback reads very well and is technically difficult to fault on the above score except that in many places (including the index) hydrogen embrittlement is described as hydrogen-brittlement.

The book reviews available information on the theory and practice of applying corrosion inhibitors and this is supplemented by data obtained from the authors' own research and practical work. In all, over 330 references are included of which, surprisingly enough, only just over one third are to the Russian literature.

After a brief historical introduction describing the growing applications for corrosion inhibitors, with particular reference to Russian practice, the book is divided into six main chapters dealing with the classification of inhibitors and the laws governing their action (I); concepts of the mechanism of protection action of inhibitors (II); corrosion inhibitors in aqueous solution of acids (III), alkalis (IV), and salts (V). Chapter V also deals with atmospheric corrosion inhibitors and there is a final chapter on inhibitors in non-aqueous liquid media.

This is essentially a book for the metallurgist or chemist who is actively interested in the corrosion of metals and as such provides a valuable review of the literature coupled with details of work carried out in Russia. As a sop to the practical man, some applications are given in 5 Appendices which bear a marked resemblance to trade literature. The first deals with "the use of pickling additive CHM" with which are used pickling regulator "R" and foaming agent "P." The remainder deal with Russian practice for rust removal using acid solutions or pastes, the use of hydrochloric acid for dissolving boiler scale and the use of paper impregnated with monoethanolamine carbonate for protection against atmospheric corrosion.

It seems that for the practical man there is little if anything new to be learned from Russian practice as described. The book is of undoubted value to the corrosion scientist but sixty three shillings seems a high price for a typewritten script reproduced by some photo-copying technique. What a pity one chapter and the index are in an entirely different type size to the rest of the book and there are so many changes of carbon paper.

H. A. HOLDEN.

A Survey of Nickel and Chromium Recovery in the Electroplating Industry, by E. P. Harris, A.R.S.M., B.Sc., F.I.M. Issued free by the Department of Scientific and Industrial Research, 5-11 Regent Street, S.W.1 43 pp.

Wastage of nickel and chromium salts in the electroplating industry is not only substantial but often causes a pollution problem to both the electroplater and the drainage authorities. The results of a survey by the Department of Scientific and Industrial Research in co-operation with the British Non-Ferrous Metals Research Association and the electroplating industry are published in this book and methods of eliminating wastage and the reduction of pollution are discussed. Nickel and chromium salts are largely wasted by "drag-out" when the solution is carried away by plated articles as they leave the plating bath. Out of an estimated total weight of 2870 tons of nickel used by the plating industry in 1958, about 290 tons

represented the metal content of the nickel sulphate and chloride used; these chemicals increase the total material cost by about thirteen per cent. but the use of a simple static rinse tank has been found to eliminate three-quarters of the cost of these added salts. Reduction in water consumption by the use of counter-flow rinses is also recommended and the author indicates that there is great potential value in the ion-exchange process for the purification and re-use of effluent solutions.

Industrial Finishing Year Book, 1960. The Arrow Press Ltd., 1 Stamford Street, London, S.E.1. 296 pp. Free to subscribers to "Industrial Finishing" or 15s. post paid.

This book covers as far as possible in a single volume the whole field of industrial finishing and contains a wealth of information, much of it in tabular form, grouped for convenience and easy reference under various headings. A short opening section on workshop practice contains brief facts on material handling, safety equipment, flooring, air conditioning and protective clothing. Besides comprehensive tables listing cleaning solutions, the physical characteristics of electro-deposited coats, the properties and uses of synthetic coatings, polishing wheel grit sizes, metal colouring treatments and the physical constants of oils, there are tables referring to the faulty deposits from plating baths and how to correct them and suggested metal etching procedures. There is also much to read on paints, pigments and corrosion protectives.

LOWER PRICES FOR INDUSTRIAL SOLVENTS

THE General Chemical Division of the Imperial Chemical Industries have reduced the price of two important industrial solvents—trichloroethylene and perchloroethylene—as from January 1, 1961, the price of the former being reduced by £1 per ton and that of perchloroethylene by £5 per ton; the products are known in the dry-cleaning industry as "Triklone" and "Perklone" respectively. These reductions have been made possible by greater output following increased demand. When similar price reductions were announced a year ago, I.C.I. disclosed plans for a £1 million extension to the solvents plant operated by the General Chemical Division at Run-corn, Cheshire; this project is now well advanced and production is expected to start next summer.

MEETINGS OF THE MONTH

January 18

Institute of Vitreous Enamellers (Southern Section). "Jewellery Enamelling" by A. C. Ore, at the Constitutional Club, Northumberland Avenue, London, W.C.2. 7.15 p.m.

January 19

Institute of Vitreous Enamellers (Midland Section). "De-enamelling Processes" by R. Williams, at the Station Hotel, Dudley, Staffs. 7.30 p.m.

January 24

Institute of Metal Finishing (South-West Branch). "Metal Degreasing and Trisec Drying" at the Royal Hotel, Cardiff. 7.30 p.m.

January 25

Institute of Metals (Manchester Metallurgical Society). "The X-ray Microanalyser as a Research Tool for the Metallurgist" by D. A. Melford, M.A., Ph.D. at the Manchester Literary and Philosophical Society, George Street, Manchester. 6.30 p.m.

January 26

Institute of Metals (Southampton Metallurgical Society). "Hot Dip Galvanizing" by M. H. Davis, B.Sc. at the Southampton University. 7.15 p.m.

January 27

Institute of Metal Finishing (Sheffield and North-East Branch). "Electroplating processes — effect on Fatigue and on the Embrittlement of the Substitute," by C. Williams at the Grand Hotel, Sheffield. 7.0 p.m.

Institute of Vitreous Enamellers (Midland Section). Annual Dinner at the Station Hotel, Dudley. 7.15 p.m. for 7.30 p.m.

January 28

Institute of Metal Finishing (North-West Branch). Annual Dinner and Dance at the Kent Suite, Belle Vue, Belle Vue Gardens, Manchester. 6.0 p.m. for 6.30 p.m.

January 31

Society of Instrument Technology (Data Processing Section). "Instrumentation Past, Present and Future" by L. S. Yoxall at Manson House, 26 Portland Place, London, W.1. 6.30 p.m.

February 2

Institute of Metal Finishing (North-West Branch). "Paints for the Sixties" by E. Johnson at the Apprentice School, De Havilland Propellers, Ltd., Lostock, Bolton. 7.30 p.m.

Institute of Metals (Birmingham Local Section). Students evening. Conversazione and Exhibition at the College of Technology, Gosta Green, Birmingham. 6.30 p.m.

February 7

Institute of Metal Finishing (Midlands Branch). Brains Trust on Precleaning, Rinsing and Drying at the James Watt Memorial Institute, Great Charles Street, Birmingham, 3. 6.30 p.m.

Institute of Metals (Leeds Metallurgical Society). "Metals in Antiquity" by R. F. Tylecote, M.Sc., M.A., Ph.D., A.M.I.E.E., F.I.M. at the Metropole Hotel, Leeds. 6.30 p.m.

Institute of Vitreous Enamellers (Scottish Section). "Furnaces and Enamelling Equipment" by T. M. Lees, at the Plough Hotel, Stenhousemuir. 7.15 p.m.

February 8

Institution of Mechanical Engineers. "The Influence of Measuring Force, Stylus Radius and Surface Finish on the Accuracy of Measurement of Work Pieces by a Comparator" by L. W. Nickols and T. R. J. Oakley, "An Investigation into the Accuracy of Industrial Measurement of Sizes between 0.02 and 5 in.," by P. W. Harrison, at 1, Birdcage Walk, London, S.W.1. 6.0 p.m.

Institute of Metal Finishing (Organic Finishing Group). "Paints and Painting in the Sixties," by E. Johnson at the British Institute of Management, Management House, 80 Fetter Lane, London, E.C.4. 6.30 p.m.

Institute of Metals (Manchester Metallurgical Society). "Residual Stress and Stress Relieving" by L. E. Benson, D.Sc., F.I.M. at the Manchester Literary and Philosophical Society, George Street, Manchester. 6.30 p.m.

February 9

Institute of Metals (Liverpool Metallurgical Society). "The Origin and Solution of Some Industrial Corrosion Problems" by E. C. Campbell at the Department of Metallurgy of the University of Liverpool. 7.0 p.m.

February 16

Institute of Metals (North-East Metallurgical Society). "Plastics versus Metals" by P. T. Moore, B.Sc., Ph.D., D.I.C., A.R.S.M., A.I.M. and H. Hughes, B.Sc. at the Cleveland Scientific and Technical Institution, Corporation Road, Middlesbrough, 7.30 p.m.

February 20

Institute of Metal Finishing (London Branch). "Some Electroplating Problems in Mould Electroforming" by P. Spiro at the Northampton College of Technology, St. John Street, London, E.C.1. 6.15 p.m.

February 21

Institute of Metal Finishing (South-West Branch). "Electrochemical Machining" by D. Hughes at the Saracen's Head Hotel, Gloucester. 7.30 p.m. Joint meeting with the Gloucester Engineering Society.

Institute of Metals (West of England Metallurgical Society). "Metallurgy in Modern Jewellery" by Miss Dorothy Pile, A.I.M. at the College of Technology, Ashley Down, Bristol, 7. 7.30 p.m.

February 23

Institute of Vitreous Enamellers (Midland Section). "Industry's Requirements of Detergent Resistance" by D. Lloyd at the Birmingham Exchange and Engineering Centre, Stephenson Place, Birmingham, 2. 7.30 p.m.

February 24

Institute of Metal Finishing (Midland Branch). Dinner and Dance. Grand Hotel, Birmingham. 6.45 p.m.

THE GOLDEN MOTOR CYCLE

TWO years ago at the Motor Cycle Show, Norton Motors introduced their 250 c.c. "Jubilee" Motor Cycle. At the recent Golden Jubilee of the Motor Cycle and Cycle Exhibition, Norton displayed a Golden "Jubilee." All parts of the machine normally chromed were gold plated, and all parts and accessories normally painted were finished with a special polychromatic gold lacquer made by Pinchin Johnson.

Latest Developments **in** **PLANT, PROCESSES AND EQUIPMENT**

Protection of Chrome and Other Metals

THE Goodyear Tyre and Rubber Co. (Akrón, Ohio) have produced a tough plastic coating in a resin or pellet-like form — "Vitel," which can be made into clear or tinted liquid solutions that form hard, glossy protective films adhering well to chrome, aluminium, steel and other metals and will not peel off. The coating prevents rust and tarnishing and has excellent scratch and abrasion resistance; tests show that hubcaps coated with Vitel still look new after more than a year of actual service over all types of roads and in all types of weather; washing with clear water restores the original lustre. The coating can be applied by brushing or dipping or can be adapted to handy spray applicators.

Photo Resist for Etched Copper Circuits

THE Meaker Co., Nutley 10, New Jersey, U.S.A., a subsidiary of the Sel-Rex Corporation, have produced a new photo resist, "Resist-Etch", which is said to positively block off unwanted electroplate and to permit accurately defined electroplated patterns in printed circuits calling for lines 0.005 in. wide spaced 0.005 in. apart, even when used by relatively unskilled labour. Other features are said to be freedom from pinholes, not affected by all plating cycles, yet easily removed by its companion product Resistrip, will not contaminate base or precious-metal plating solutions and freedom from toxicity.

Long Life Sealable Envelope

ENVOPAK Ltd., of Powerscroft Road, Sidcup, Kent, have produced a simple and effective closure consisting of a flanged metal cap as an improvement on the "Envopak," a re-usable zip-fastened container made from PVC-coated nylon designed to supersede expendable envelopes and canvas mailing bags for mail bound for the same destination, *e.g.* between branch and head offices. The "Envoseal", as the new closure is called, is snapped into position by the despatcher and broken by the receiver with the aid of a metal opener and cannot be taken off without breaking it so that tampering is immediately detected; it is claimed to be more efficient than any other form of closure, such as padlocks, metal seals, tape or sealing wax.

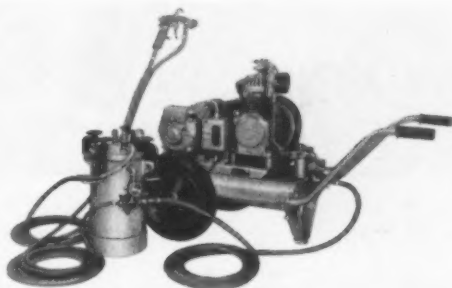


Fig. 1—Portable paint spraying equipment

Portable Paint Spraying Equipment

FIG. 1 shows the "Volspray Six" paint spraying equipment produced by Volspray Ltd., Grosvenor Gardens House, London, S.W.1., which can be supplied with a 4-stroke, air-cooled, petrol engine, or for operation from a.c. mains, single phase, 50 cycles, 100/110, 200/220 and 230/380 volts., three phase, 50 cycles, 400/440, 346/400, and 220/380 volts, or from d.c. mains at 100/110 and 220/250 volts. The model incorporates a twin cylinder air-cooled air compressor 2 in. bore by 2 in. stroke, 780 r.p.m., a hand and automatic air governor which automatically permits the compressor to run light when the maximum pressure is reached and an air inlet filter which is easily removed for cleaning.

Electronic Reading Automaton

THE Solartron Electronic Group Ltd., of Farnborough, Hants., have designed a unit known as the Electronic Reading Automaton, which reads printed characters at very high speed and emits coded signals corresponding to the characters, which may be fed directly into a computer, be used to drive a card punch, or to punch paper or to write on magnetic tape. The reading speed is over 300 characters per second from either continuous rolls of paper or separate documents. The tally roll is the most compact form for recording transactions and lends itself to the use of standard recording equipment such as cash registers, adding machines and ledger machines. The size of separate documents that can be read is 6 in. by 3 in. to foolscap.

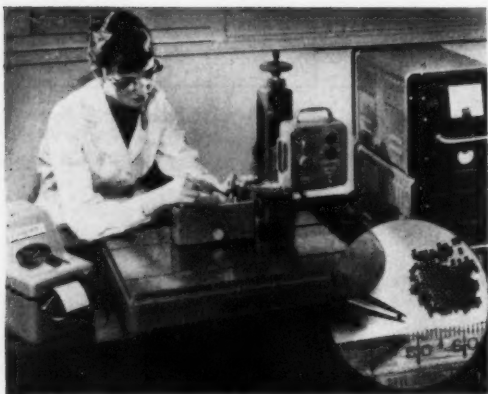


Fig. 2 Measuring surface finish of spherical bearing

Surface Measurement of Spherical Bearings

AMONG the exhibits by the Taylor, Taylor, and Hobson Division of Rank Precision Industries Ltd. at the Physical Society Exhibition being held at the Royal Horticultural Society's Halls at Westminster, London, S.W.1, is a prototype of a new development that enables the surface finish of small ball bearings to be measured and recorded accurately in half-millionths of an inch. The instrument, which is shown in Fig. 2, is designed for use with the Talysurf Model No. 3 Surface Measuring Instrument and consists of a stationary pick-up unit in which a stylus is mounted underneath a conical seating; the ball to be tested is placed in the seating where it is then rotated by a friction drive, controlled from the standard Talysurf gearbox; the ball is given the same surface velocity as is normally applied to the traverse of the Talysurf pick-up in its conventional form, allowing both graphs and average readings to be obtained from a standard Talysurf 3. The range of balls catered for is 1 mm. to 1 in. and graph readings are recorded with magnifications up to $\times 50,000$ (1/10 in. on paper representing 0.000002 in.).

Another accessory for the Talysurf Model No. 3 instrument is a cylindrical datum attachment for dealing with convex and concave radii from 2 in. to infinity. Also on show is an instrument, Talysurf Model No. 3, which will measure the surface finish inside cylinders of $\frac{1}{4}$ in. diameter to a depth of 10 in. and provides centre line average readings with 0.03 in. cut-off; it is portable and suitable for a wide range of workshop and inspection applications.

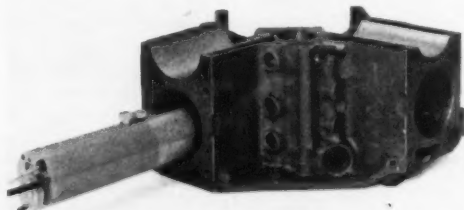
Improved Nickel Plating System

THE Electro-Chemical Engineering Co. Ltd. of Sheerwater, Woking, Surrey, have produced a system of dual coating of nickel, Efco-Udylite Bi-Nickel, consisting of N2E sulphur-free semi-bright nickel followed by 66 bright nickel, which is said to improve the outdoor resistance of chromium plated components and gives good results in marine and mobile exposure and also in accelerated corrosion tests. The N2E deposit can be applied to any of the basis metals which are normally plated with bright nickel, such as suitably polished steel articles, copper plated zinc-base die-castings, brass components, etc., and gives ductility and freedom from pitting; the 66 deposit gives a high degree of adhesion and has high levelling, high lustre and good ductility characteristics.

Measurement of Internal Profiles

FIG. 3 shows the Proficorder Internal Linear Piloter manufactured by the Micrometrical Manufacturing Co., 3621 South State Road, Ann Arbor, Michigan, as an accessory to the Proficorder, an electromechanical instrument for measuring and recording flatness, roundness, waviness, roughness, flaws and total profiles of practically any types of surface that can be produced by normal production methods. The Piloter makes it possible to measure deep, round, square, rectangular and triangular shaped holes, as well as many other odd shapes and sizes and avoids the necessity to cut parts in order to profile them; it is interchangeable with the linear and rotary piloters for use with a common amplicorder. A 4-in. wide strip chart used with the Proficorder permits easy reading and identification of all surface irregularities; vertical readings may be magnified thousands of times and horizontal readings many hundreds of times, permitting the detection of even the minutest surface variations.

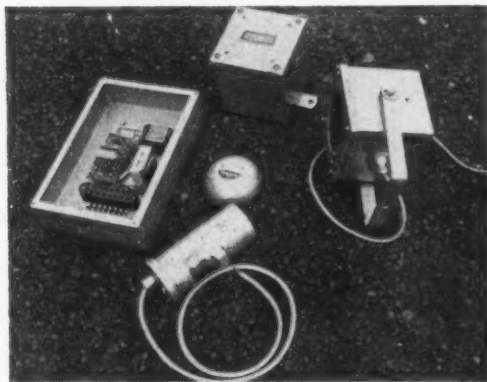
Fig. 3 Measuring internal profiles



One-Way Photo-Electric Cell

A PHOTO-ELECTRIC cell unit that will operate only when the light beam is interrupted in one direction is being produced by Hird-Brown Ltd. of 244, Marsland Road, Sale, Cheshire, who have also introduced a photo-electric cell warning system for giving audible or visible alarm in which the new technique can be incorporated. The five basic components of the warning system—the control unit, with its water-tight cover removed, the transformer, the projector, the receiver and the 3-in. diameter bell, are shown in Fig. 4. The cell is such that if an object passes through the beam in the reverse direction, nothing will happen. The warning system can be used to monitor moving webs of any material and immediately indicates when a break or tear occurs; several beams can be connected to one control unit. The warning can be set on site to sound continuously or to stop ringing after five to 15 seconds and the equipment is suitable for beam lengths of up to 75 ft. and for operation indoors or outside under wide temperature variation and under smoky conditions.

Fig. 4—Photo-electric cell warning system



Precision Diamond Paste

A PRECISION diamond paste, X-17, manufactured in Switzerland, is now available in this country through Charles Churchill and Co. Ltd., Coventry Road, South Yardley, Birmingham. The paste is supplied in twelve different grain sizes in 5-gram sealed glass syringes, designed for economy in use and freedom from spoilage by foreign matter. The grains are very accurately sorted for size and shape enabling each grain to be a working grain and avoiding irregular scratching from oversized and mis-shapen grains; it is claimed that reductions in time up to 90 per cent are possible.

Rust-proofing Metal Coating

METALIFE Liquid Metals Ltd., Station Square, Harrogate, have recently marketed a liquid metal coating, "Metalife Duplex," for rust-proofing iron and steel, which is claimed to give a double thickness coating in one brushed application and can be overcoated in six hours, thus saving application time and consequent labour costs. The coating is supplied as a two-pack system, consisting of a base and a solidifier which when combined give a coating said to have exceptional resistance to corrosion, abrasion, solvents and chemicals, withstand temperatures from 65°F. to 400 F. dry heat and is non-toxic. Two brushed applications of "Duplex" deposits 2.1 oz. of anodic metals per sq. ft., equivalent to good quality galvanizing; additional advantages are that it can be applied to damp surfaces, does not sag or drip, and settlement is negligible.

Joint Breaker

ALLWEATHER Paints Ltd., 36 Great Queen Street, London, W.C.2, have produced a liquid formulation, "Pitan Joint Breaker," specially compounded to ensure easy, safe, and speedy disconnection and removal of flanges, couplings, pipes, unions, sockets, ferrules, castings, fabrications, etc., by the emulsification of the jointing compound uniting their faces, surface or threads, in a simple way which removes the danger of destruction or damage inherent in the normal method of forcing or breaking the joint. The Pitan Joint Breaker is of medium viscosity, and is prepared for use and needs no dilution or other attention. The method of application is simply by pouring or brushing on and disturbed threads, flanges or mating surfaces can be wiped clean of all sealing compound without scraping or mutilation of any kind.

High-capacity Lightweight Air Compressor

A N air compressor designed specially for small workshop and foundry is one of the exhibits on the stand of Atlas Copco (Great Britain) Ltd. of Maylands Avenue, Hemel Hempstead, Herts., at the Public Works Exhibition, held at Olympia, London, recently. The compressor, catalogue number TT6, is a two-stage, single-acting machine with an intercooler built for a normal working pressure of 100 lb. per sq. in. and a free air delivery of 140 cu. ft. per min. and is complete with a flange-mounted electric motor. The complete power pack unit weighs only 1,050 lbs. and is mounted on rubber feet which eliminate foundation costs and enable it to be placed on concrete floors wherever it is needed.

Slotted Drumsander

FIG. 5 shows a slotted type of rubber drum sander for portable tools recently introduced by B.O. Morris Ltd., Morrisflex Works, Briton Road, Coventry, which uses centrifugal force to lock the band in position while in operation; grit changing is achieved in a matter of seconds by merely stopping the hand tool, slipping off one band and slipping on another. The slots also introduce air behind the abrasive band thereby assisting in cooling and helping to prolong both band and rubber life. 3 sizes are available—1 in. dia. by 1 in. wide by $\frac{1}{4}$ in. shank, 2 in. dia. by 1 in. wide by $\frac{1}{4}$ in. shank, and 4 in. dia. by $1\frac{1}{2}$ in. dia. and $\frac{3}{8}$ in. shank.

Fig. 5.—Slotted drumsander



Pocket Magnifier with Micrometer Scale

FIG. 6 shows a pocket magnifier with a graticule to ensure accurate readings of ± 0.002 in. which is being produced by Graticules Ltd., Bath House, 57/60, Holborn Viaduct, London, E.C.1. The magnifier folds into a neat square measuring $2\frac{1}{8}$ in. by $1.7/16$ in. by $9/16$ in.; the frame is aluminium, cut away to give a field of vision of 1 in. and the graticule, which is bonded to glass by a process evolved by Graticules Ltd., is resistant to heat, chemical attack and abrasion and can be replaced in the event of breakage.

Fig. 6.—Pocket magnifier



Tank/Transducer Assembly for Ultrasonic Cleaning

THE Dawe, Type 1160/T52 $1\frac{1}{2}$ gallon (B.I.) ultrasonic cleaning tank, Fig. 7, manufactured by Dawe Instruments Ltd., 99-101, Uxbridge Road, Ealing, London, W.5, is designed for use with the Dawe, Type 1150 500/125 W generator, and has a 40 kc/cs piezo-electric transducer mounted within the tank base, covering the full floor area. The unit is built of welded stainless steel, with internal tank dimensions of 8 in. by $6\frac{1}{2}$ in. by 10 in. deep. The overall depth is $13\frac{1}{2}$ in. and has a 1-in. flange at the upper edge, enabling the unit to be mounted in a bench aperture.

The unit is suitable for small part production line cleaning, surgical instrument and hypodermic needle and syringe cleaning, and for laboratory and experimental work on cleaning, plating, solvent acceleration and tissue disintegration.

Fig. 7.—Ultrasonic cleaning equipment



Standard Unit Construction Spray Booths

T.C. Spray Finishing Systems (Bede) Ltd., of 5 St. James's Place, London, S.W.1. have designed a standard unit system whereby a booth of any height, width or breadth is put together to fit in with the paint shop layout. The design is simple, quick and cheap to instal and covers a wide range in size and purpose. The principle types of booth built on the standard unit principle are dry back booths, wet back spray booths and hot airless spray low velocity booths.

(Continued in page 44)

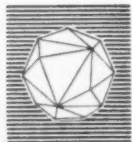


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Silver addition agents provide the fastest silver plating process and the brightest finish for electrical contacts. With PLUSBRITE Silver the deposit of metal is unalloyed and retains its full electrical conductivity. PLUSBRITE Silver addition agents assist in forming an exceptionally hard deposit of bright silver, which notably resists tarnish. They are finding use also in a wide range of silver-plated products.

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Telephone: Kensington 3422

Emulsifiable Degreaser

ISAAC Bentley and Co. Ltd., Trafford Park, Manchester 17, have produced a grease solvent of the emulsifiable type, "Fleetex," which can be made up in solution for removing polishing compositions from components, cleaning machinery and machine parts and cleaning floors which are heavily encrusted with grease and dirt.

Research and Industrial Polarograph

THE Tinsley Polarograph Mark 200, Fig. 8, manufactured by Evershed and Vignoles Ltd., of Acton Lane, London, W.4, is an advanced instrument designed for both research and industrial requirements and suitable for applications covering investigations into electro-chemistry, stability constants of reducible compounds and characterization of certain complex organic materials. It is capable of trace determination of materials in solution to better than 0.02 p.p.m. The d.c. circuit employed permits operation from any type of electrode system, i.e. D.M.E. vibrating and rotating solid electrodes, or pool electrodes, etc. The electrode may be positive or negative with respect to the reference electrode. The design embodies a galvanometer transistor d.c. amplifier which uses two parallel feed back circuits to adjust sensitivity in one feed back loop and speed of response in the other.

The potentiometer recorder itself has an effective chart width of 200 mm. allied to a response time of 1 second and embodies its own integral amplifier; two chart speeds are provided and the overall sensitivity of the polarograph covers from 0.02—100 micro-amperes for full scale deflection. A particularly interesting feature is the provision of a peak reading unit which eliminates capacity current noise from the normal D.M.E. and thus permits the chemist to obtain virtually undamped polarograms at all sensitivities without loss of resolution on both direct and derivative polarograms. Conventional damped polarograms may also be recorded (derivative type damping is used) and little or no zero shift will occur either with direct or derivative polarography. The potentiometer covers a voltage span from +0.5-3 and reverse with 5 scanning speeds for increased resolution.

The polarograph is housed in a metal case, finished to very high standards and makes use throughout of transistorized circuitry and printed circuits arranged in plug-in units to facilitate servicing and maintenance. The potentiometric recorder may also be used as a recording microammeter over its working range, without modification as suitable switching is provided.

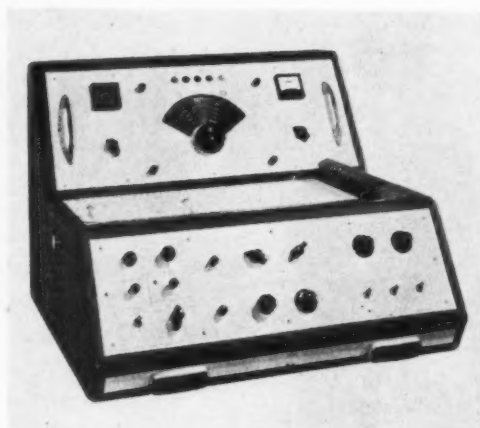


Fig. 8—Research and industrial polarograph

Terylene Industrial Clothing

WILLSON Brothers of Epsom Ltd., Willbro Works, Epsom, Surrey, have recently commenced the manufacture of terylene clothing for the chemical and other industries where working conditions include acid-laden atmospheres. Terylene protective clothing has undergone stringent tests at the works of I.C.I. Metals division at Witton and after two years wear in acid-laden atmosphere, terylene boiler suits have shown little more than normal wear, whereas cotton clothing was degraded after only four weeks' wear. A large electroplating works has changed over to terylene industrial clothing after a four-years-trial after confirming that these garments lasted three or four years against only one month's wear with cotton garments.

The results of a complete acid exposure test on 100 per cent terylene overall cloth and 100 per cent cotton drill material are given below. The strips of fabric were immersed for one hour at 30°C. in various types and constituents of acids.

Acids	Percentage concentration (w w)	Percentage loss in strength after 1 hour steep at 30°C.	
		cotton	spun terylene
Sulphuric	10	5	0
	30	27	0
	50	62	0
Hydrochloric	10	5	0
	36.5	100	0
Nitric	10	0	0
	30	7	0
	50	38	0
	70	Fabric shrunk	0
Phosphoric	88	30	0

(Continued in advt. page 21)

Plant, Processes and Equipment

(Continued from Edit. page 44)

Improved Surface Treatment for Aluminium

A CHEMICAL surface treatment for aluminium which greatly improves the adhesion of paints, lacquers, enamels, adhesives and other coatings to the metal is one of the advantages claimed to result from the use of Chemlok 720, for which the sole selling agents in Britain are Durham Raw Materials Ltd., 1-4, Great Tower Street, London, E.C.3. With air-dried lacquers and enamels (acrylic, cellulosic, butyrate, etc.), adhesion unmatched by any previous treatment is claimed and improved results are obtained with baked finishes (acrylic, vinyl, urea alkyd, melamine alkyd, epoxy alkyd, epoxies, etc.). Adhesion obtained is stronger than the coating applied and the paint film will fail cohesively rather than peel, which means that new highly-resistant paints and coatings adhere until completely weathered away. The high level of adhesion results from a chemical reaction forming polar organo-aluminium compounds of molecular thickness at the aluminium surface and producing an organic surface which exhibits greater compatibility and adhesive strength with the organic coatings subsequently applied. The treatment is cathodic and prevents under-cutting and blistering commonly encountered with anodic treatments. The process is fast, simple, economical and produces no sludge in treatment tanks.

Nickel-Phosphorus Plate to Resist Extreme Corrosion

ONE of the metallurgical products expressly designed for use in the aircraft industry on how at the S.B.A.C. this year was a nickel-phosphorus plate, Kanigen, produced by Albright and Wilson (Mfg.) Ltd. of 1 Knightsbridge Green, London, S.W.1., and used on the gun blast tubes now being fitted on the English Electric "Lightning." The plate is 1000 V.P.N. hard after heat treatment and is resistant to corrosion, erosion and wear; its use on light metal in place of steel in control valves, engine components, etc., can lead to considerable saving in weight.

Contact Adhesive

ALLWEATHER Paints Ltd., 36 Great Queen Street, London, W.C.2., have produced a contact adhesive, Pitan Contact Adhesive No. 1, consisting of a solution of mixed synthetic rubbers blended with a reinforcing resin, which is claimed to bond metal, plastic, wood and rubber to themselves and to wall surfaces of plaster and concrete. The adhesive is packed in 5-gallon drums, and 1-gallon, ½-gallon, quart and pint cans.

Classified Advertisements

repaid rates: FIFTEEN WORDS for 7s 6d. (minimum charge) and 4d. per word thereafter, or 24s. per inch. Box number 2s. 6d. including postage of replies.

SITUATIONS VACANT

CHEMIST IS REQUIRED to take charge of Control Laboratory of large Nickel/Chromium Plating Plant near Cardiff. Graduate of H.N.C. or similar qualification preferably with some experience of plating required. Send full details stating age, qualifications and salary required to Box. CI 236.

EDUCATIONAL

Lanchester College of Technology Coventry

COURSE ON

"Modern Trends in the Theory and Practice of Electroplating"

A short course will be held on Thursday and Friday, February 2nd and 3rd, 1961. Course Fee £1 2s. 0d. Further details and application forms from the Head of the Chemistry Department, Lanchester College of Technology, Priory Street, Coventry.

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VITREOUS ENAMELLING PLANT

2 MUFFLE HANGING FURNACES. Incandescent Heat Co., Oil converted to gas fired. 14' 6" x 5' 7" deep x 2' 10" wide overall. Complete with chargers, adjacent self-heated drying chambers, recording and controlling equipment.

MUFFLE FLAT FIRING FURNACE. Incandescent Heat Co., Gas fired. 7' 6" x 3' 6" wide x 2' 9" deep overall. Complete with charger, recording and controlling equipment.

PEBBLE MILLS. Steele and Cowlshaw. One each 5cwt., 200lbs., 63lbs. Four 143lbs.

DOUBLE JAR MILL. 6lbs. each.

Tilghman ROOM SHOTBLAST. Hand rotated table 6' dia with 4' high division. Room 7' sq. x 8' high. Cyclone.

Tilghman WHEELABRATOR with Steel Conveyor 3' 3" x 3' dia. 4 speeds and reverse.

Tilghman SHOTBLAST BARREL converted to cabinet 2' 6" x 1' 11" floor. Cyclone.

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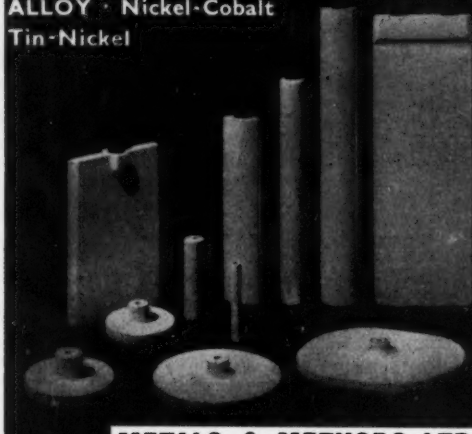
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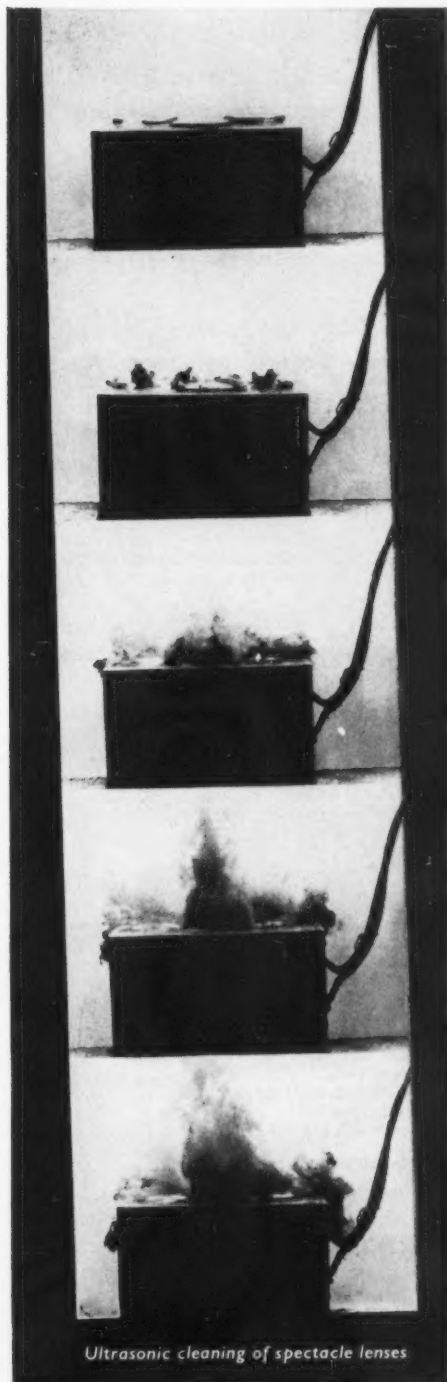
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